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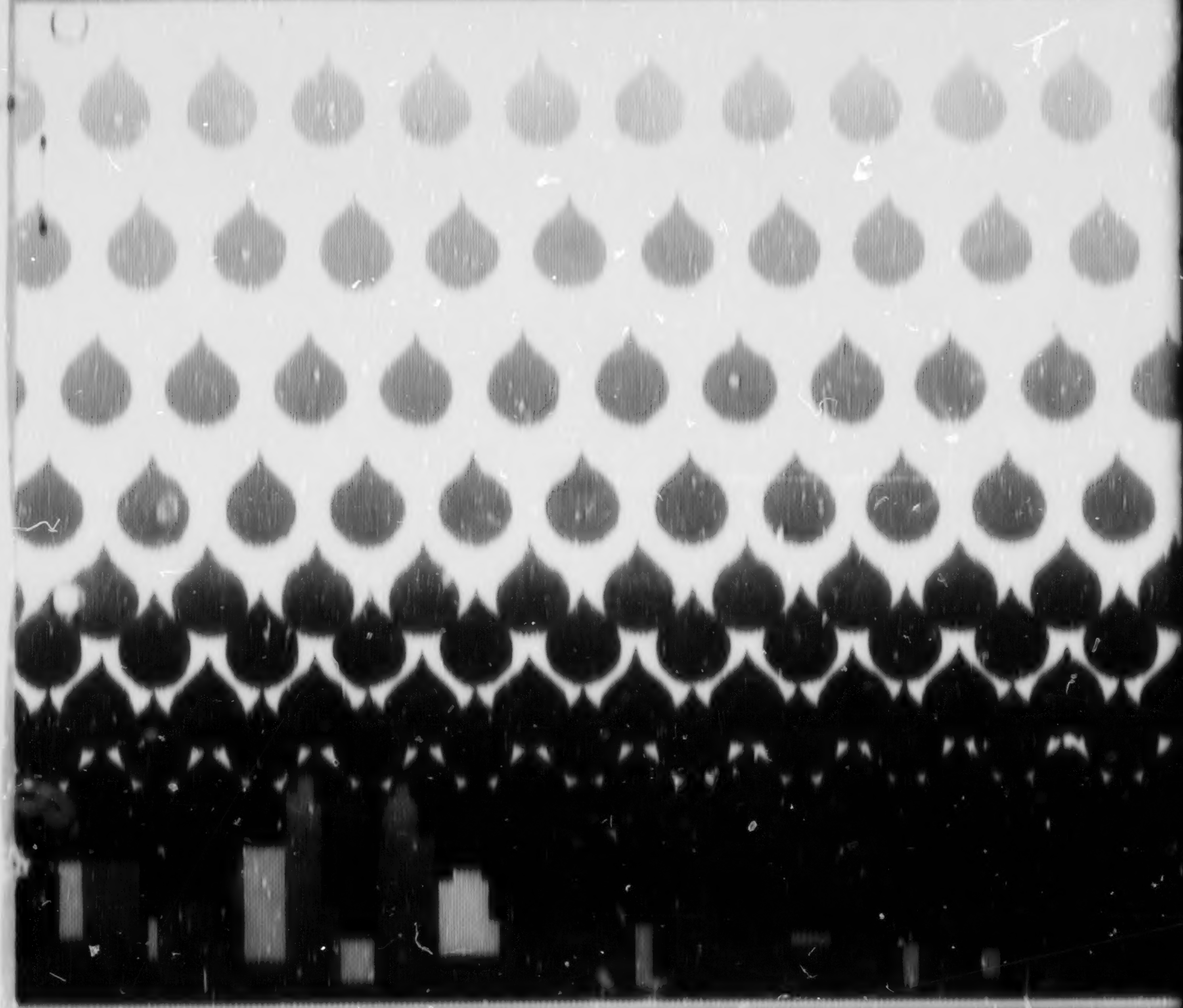

Urban Rainfall-Runoff-Quality Data Base

Municipal Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

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16. ABSTRACT

Urban rainfall-runoff-quality data gathered by others have been assembled on a storm event basis for one or more catchments in the following eight cities: San Francisco, CA; Broward County, FL; Lincoln, NB; Durham, NC; Windsor, ONT; Lancaster, PA; Seattle, WA; and Racine, WI. Rainfall-runoff data have been assembled for one or more catchments in an additional 13 cities: Baltimore, MD; Chicago, IL; Champaign-Urbana, IL; Bucyrus, OH; Falls Church, VA; Winston-Salem, NC; Jackson, MS; Wichita, KS; Westbury, NY; Philadelphia, PA; Los Angeles, CA; Portland, OR; and Houston, TX. The 21 cities contain data for a total of 41 catchments. Descriptions of the catchments, parameters and sampling procedures are provided in this report. Actual data have been placed on a magnetic tape and will be placed on the EPA STORET data retrieval system in the future. Additional data for the above cities and data for other cities will be included in the form of addenda to this report. Although none are presently included, data collected as part of current EPA Section 208 Areawide Waste Management studies are expected to augment the data base in the future.

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URBAN RAINFALL-RUNOFF-QUALITY DATA BASE

by

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Project No. 68-03-0496

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FOREWORD

The US Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water supplies and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research, a most vital communications link between the researcher and the user community.

This report documents urban rainfall, runoff and quality data available for testing of urban hydrologic and water quality models and characterization of component processes. Quality data are included for eight cities with rainfall-runoff data only for an additional 13 cities. Many potential locations of data are also discussed.

Francis T. Mayo
Director
Municipal Environmental
Research Laboratory

PREFACE

A common denominator of mathematical models of urban hydrologic processes is the need for adequate data with which to calibrate and verify model representations of physical processes. Such data need to be collected at short time intervals during several storms and are typically time consuming and expensive to obtain. However, the data also serve the very useful purposes of characterization of urban rainfall-runoff-quality processes in terms of statistics and loadings (e.g., pounds per acre) and extrapolation of such characteristics to ungaged catchments. It has been difficult in the past to obtain data for either modeling or characterization purposes.

This project was initiated on the assumption that many such data must exist; they need only be "found" in unpublicized deposits in widely scattered firms, universities and government agencies. The results of searching for these data indicate that there are indeed many potential sources, but the accessibility and documentation of most are deficient enough to render them difficult to use at best. However, the data for 41 catchments in 21 cities documented in this report represent a first effort to aggregate available data into one accessible data base. Note that the emphasis has been upon assembling and processing of data rather than construction of a sophisticated computerized data storage and retrieval system. EPA's STORET system will be used for the latter purpose in the future. At present, the data base itself consists of a magnetic tape with data organized in a readily accessible format.

The project has depended entirely upon the cooperation and good will of groups who have contributed their data. The University of Florida and EPA actively solicit new data from all sources in order to improve the data base described in this report. Holders of useful data are encouraged to contact UF directly. UF has also been designated as a recipient of data collected under EPA Section 208 studies; however, most 208 studies are at too early a stage to provide results in the near future. The overall goal is to build upon this initial effort in order to provide a large enough data base to allow selectivity in choice of model calibration-verification procedures and to provide statistically significant urban runoff characterizations.

ABSTRACT

Urban rainfall-runoff-quality data gathered by others have been assembled on a storm event basis for one or more catchments in the following eight cities: San Francisco, CA; Broward County, FL; Lincoln, NB; Durham, NC; Windsor, ONT; Lancaster, PA; Seattle, WA; and Racine, WI. Rainfall-runoff data have been assembled for one or more catchments in an additional 13 cities: Baltimore, MD; Chicago, IL; Champaign-Urbana, IL; Bucyrus, OH; Falls Church, VA; Winston-Salem, NC; Jackson, MS; Wichita, KS; Westbury, NY; Philadelphia, PA; Los Angeles, CA; Portland, OR; and Houston, TX. The 21 cities contain data for a total of 41 catchments. Descriptions of the catchments, parameters and sampling procedures are provided in this report. Actual data have been placed on a magnetic tape and will be placed on the EPA STORET data retrieval system in the future. Additional data for the above cities and data for other cities will be included in the form of addenda to this report. Although none are presently included, data collected as part of current EPA Section 208 Areawide Waste Management studies are expected to augment the data base.

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ABBREVIATIONS

APWA	American Public Works Association
ARS	Agricultural Research Service
ASCE	American Society of Civil Engineers
COA	Canada - Ontario Agreement
Colif	Coliforms
DWF	Dry Weather Flow
ENDEX	Environmental Data Index (data retrieval system of NOAA)
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
FWPCA	Federal Water Pollution Control Administration
FWQA	Federal Water Quality Administration
GPO	Government Printing Office (Washington, D.C. 20402)
HEC	Hydrologic Engineering Center of the Corps of Engineers
HSP	Hydrocomp Simulation Program
Hwy	Highway
IASH	International Association for Scientific Hydrology
IHD	International Hydrological Decade
ILLUDAS	Illinois Urban Drainage Area Simulator
Ind	Industrial
JWPCF	Journal of the Water Pollution Control Federation
METRO	Municipality of Metropolitan Seattle
NAWDEX	National Water Data Exchange (data retrieval system of the USGS)

ABBREVIATIONS (concluded)

NERC	National Environmental Research Center
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
NTIS	National Technical Information Service (5285 Port Royal Rd., Springfield, Virginia 22161)
NWS	National Weather Service
OASIS	Oceanic and Atmospheric Scientific Information System (data retrieval system of NOAA)
OWRT	Office of Water Resources Technology
PHS	Public Health Service
Res	Residential
RRL	Road Research Laboratory of Great Britain
Set	Settleable
Sol	Soluble
STORET	Storage and Retrieval (data retrieval system of the EPA)
STORM	Storage, Treatment, Overflow, Runoff Model
Susp	Suspended
SWMM	Storm Water Management Model
Tot	Total
UF	University of Florida
US	United States
USGS	United States Geological Survey
WATSTORE	Water Data Information and Retrieval System (data retrieval system of the USGS)
WMO	World Meteorological Organization

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At the University of Florida, several staff members made important con- tributions. Coding, retrieval and transferal of the data were supervised by Scientific Programmer, W. Alan Peltz. Data reduction, cross checking and figure preparation were performed by William C. Taylor. Much of the original data reduction was organized by Harry L. Crotzer. The first structure of the data base was devised by Amuri A. Arroyo. Dedicated typing was performed by Grace Provenza. Computations were performed at the Northeast Regional Data Center at the University of Florida.

SECTION I

CONCLUSIONS

Since 1974, the University of Florida has been engaged in aggregation of urban rainfall-runoff-quality data collected by others. These data are intended primarily for urban runoff model calibration and verification, characterization of urban runoff on a nationwide basis, and synthesis of data for new locations.

Locations for which data have been assembled and placed on a magnetic tape are shown in Table I-1 and Figure I-1. Rainfall, runoff and quality data are available for eight locations while the remaining number have only rainfall runoff data at present. Data are provided on a storm event basis; no long-term (continuous) records are presently included. Receiving water data are also not included.

Many of these sources may be updated using data collected more recently or using data presently being collected under various programs. In particular, EPA-sponsored Areawide Waste Management (Section 208) Studies will augment greatly the amount of data presently available. As noted in Section V, a large volume of urban runoff data already exists, much of which may be included in the data base at a future date.

The project results are provided in three forms:

1. The final report (this volume), which includes descriptions and references of data sources utilized and pending.
2. A magnetic tape containing the actual rainfall-runoff-quality data from each source on a storm event basis. Copies of the tape will be provided at cost. In addition, it is likely that all data will be placed on the EPA STORET data retrieval system for more general accessibility.
3. A limited amount of in-house modeling data (maps, plans, photos, etc.) at UF, available for short-term loan.

As new data are incorporated into the data base, addenda to this report will be issued. The University of Florida and EPA actively solicit new and additional data of the type found herein. As these data are received and processed, addenda to this report will be issued.

Table 2-1. Summary of Data - April 1977

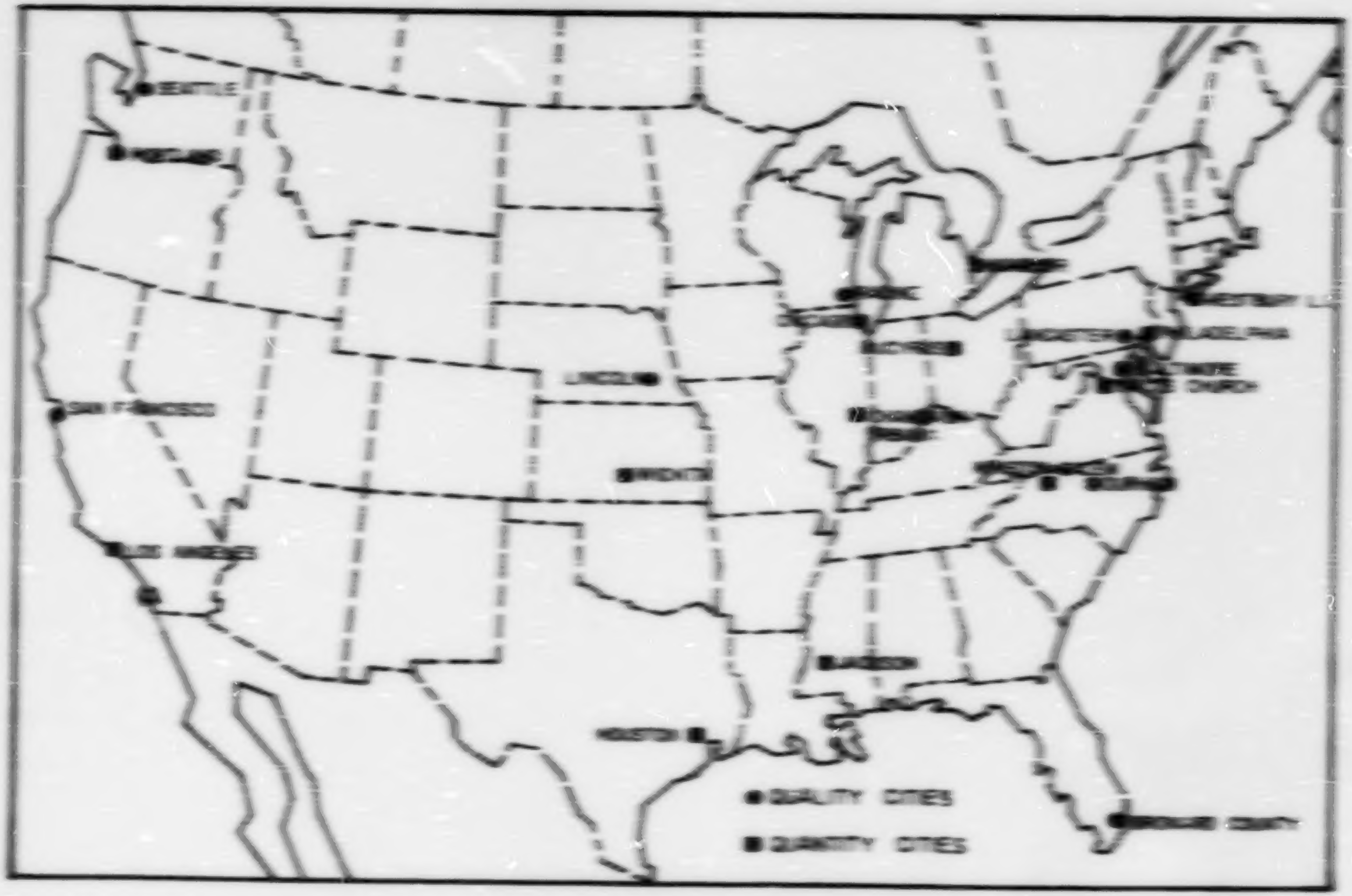
Location	Catchment	Area ac	Area (ha)	Drainage^b System	No. Storms with Quantity	No. Storms with Quality
Broward County, FL	Residential	47.5	(19.2)	S	38^a	35^a
	Commercial	39.0	(15.8)	S	14^a	14^a
	Transportation	28.4	(11.5)	S	14^a	4^a
San Francisco, CA	Baker St.	168	(68)	C	4	4
	Mariposa St	223	(90)	C	4	4
	Brotherhood Way	180	(73)	C	4	4
	Vincente St., N.	16	(6.5)	S	1	1
	Vincente St., S.	21	(8.5)	S	1	1
	Selby St.	3400	(1380)	C	8	8
	Laguna St.	375	(152)	C	2	2
Racine, WI	Site I	829	(336)	C	9	9
Lincoln, NB	39 & Holdrege	79	(32)	S	20	20
	65 & Holdrege	95	(38)	S	15	15
	78 & A	357	(145)	S	14	14
Windsor, ONT	Lababie Rd.	29.5	(11.9)	S	22	22
Lancaster, PA	Stevens Ave	94	(38.2)	C	7	7
Seattle, WA	View Ridge 1	630	(255)	S	30	30
	View Ridge 2	105	(43)	S	5	5
	South Seattle	27.5	(11.1)	S	31	31
	Southcenter	24	(9.8)	S	30	30
	Lake Hills	150	(61)	S	7	7
	Highlands	85	(34)	S	4	4
	Cent. Bus. Dist.	27.6	(11.3)	C	5	5
Durham, NC	Third Fork	1069	(433)	S	39	4

Table 2-1. (concluded)

Location	Catchment	Area ac	Area (ha)	Drainage System[b]	No. Storms with Quantity	No. Storms with Quality
Baltimore, MD	Northwood	47.4	(19.2)	S	30	–
	Gray Haven	23.3	(9.4)	S	29	–
Chicago, IL	Oakdale	12.9	(5.2)	C	21	–
Champaign-Urbana, IL	Boneyard Creek	2290	(927)	S	28	–
Bucyrus, OH	Sewer Dist. 8	179	(72.5)	C	18	–
Falls Church, VA	Triggs Run	332	(130)	S	20	–
Winston-Salem, NC	Tar Branch	384	(155)	S	17	–
Jackson, MS	Crane Creek	285	(115)	S	17	–
Wichita, KS	Dry Creek	1885	(762)	S	8	–
Westbury, NY	Woodoak Dr.	14.7	(6.0)	S	18	–
Philadelphia, PA	Wingohocking	5326	(2156)	C	26	–
Los Angeles, CA	Echo Park	252	(102)	S	18	–
Portland, OR	Eastmoreland	75	(30)	C	24	–
Houston, TX	Hunting Bayou (Cavalcade St.)	768	(311)	S	8	–
	Hunting Bayou (Falls St.)	2509	(1016)	S	21	–
	Bering Ditch	1894	(767)	S	18	–
	Berry Creek	3113	(1259)	S	18	–

[a] Additional data currently being reduced by USGS.

[b] C = Combined sewer, S = Storm sewer and/or open channels.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DURHAM
BROWARD COUNTY
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■ QUANTITY CITIES

Figure 2-1. Location map for cities with rainfall-runoff-quality data (quality cities) and rainfall-runoff data (quantity cities).

SECTION II

RECOMMENDATIONS

1. Rainfall, runoff and quality data are needed for model development, urban runoff characterization, data synthesis and other purposes. Hence, potential data sources should be cultivated and added to the present data base. The University of Florida (in care of the authors of this report) and EPA actively solicit all such data.

2. Confusion exists frequently as to the exact water quality parameter being reported--sampling method, type of sample (e.g., total or dissolved, fixed or volatile), laboratory procedure and units. Future providers of data should carefully document each of these items. Assignment of an EPA STORET code to the parameter provides a relatively unambiguous description.

3. Elementary statistical analyses should be applied to the extant data to provide characterization information. In addition, quality "loadings" (e.g., pounds per acre, pounds per acre per inch of rainfall) should be developed. Eventually, these results can be coupled with hydrologic, physical and demographic information to determine causative relationships.

SECTION III

INTRODUCTION AND OBJECTIVES

In an effort to provide useful planning tools for abatement of quantity and quality problems caused by urban stormwater runoff, many mathematical models have been developed to simulate the various components of urban hydrological processes (1,2). These models range from very simple, to very sophisticated, yet all share a common need--adequate data for development, calibration and verification. Specifically, these data consist of detailed measurements of rainfall, runoff and quality parameters taken at frequent intervals during storms, such that the full dynamic and spatially variable nature of the urban runoff may be studied. Since most recent urban hydrologic models define the complete hydrograph or pollutograph during a storm event, measurement of only, say, peak flows or average concentrations is inadequate for calibration of these models. Such models are being used in ever increasing applications and the need for relevant data has intensified.

Another important data requirement arises from the need to characterize urban runoff in a variety of ways. Examples of such needs are:

1) determination of rainfall and runoff volumes, intensities, peaks, durations, interevent times and associated statistics;

2) identification of quality parameters found in urban runoff;

3) determination of ranges, arithmetic and flow-weighted means, medians, variances, and other statistics of quality parameters;

4) computation of total mass emissions of quality parameters;

5) computation of quality "loadings" such as pounds per acre, pounds per curb-mile, pounds per inch of rainfall, pounds per day, etc. and combinations, and;

6) evaluation of causative relationships among rainfall, runoff, quality, demographic and abatement factors.

Several of the above needs require collection of both runoff and quality data; e.g., calculation of total pollutant loads, flow-weighted averages, etc. requires simultaneous measurement of flows and concentrations. Thus, concentration data by themselves are insufficient for many required analyses. Characterization results may then be used to synthesize data at unmonitored locations.

Data collected for characterization purposes are not always compatible with modeling needs since infrequent sampling times and/or omission of key parameters are likely. However, data suitable for model usage are usually also well suited for characterization purposes provided enough of a sample exists. It is desirable that characterization data be representative of an entire year or season and thus result from samplings of many storms since one group of data may be used for model calibration while the remaining group may be used for verification.

This project has obtained data, collected by others, to fulfill the modeling needs as first priority with attention also to the characterization needs. As described subsequently, there have been a surprisingly large number of studies devoted to collection of data useful for modeling, although collection of good quality data is more difficult and lags the quantity data by a considerable degree. The overall objective of this research, then, has been to find these data and publish them.

Specific objectives are, broadly:

1. identify sources of data,
2. establish criteria for collection of data,
3. acquire available data,
4. construct initial data base,
5. define how continuing maintenance of the data base is to be accomplished, and
6. define how data dissemination should be done.

These items are addressed individually and collectively in this report. Viable, current data sources are described within the report, and actual data from these sources have been placed for easy access on magnetic tapes. It is anticipated that the data will also be available on the EPA STORET system in the future.

The data collection and evaluation process is a continuous one, especially in light of current EPA Section 201 and 208 projects. Hence, the data sources described herein may be considered as an initial effort only. Data are continually being acquired as part of the project, and addenda with new data from new or the same sources will be issued periodically. To underscore this point, it should be noted that it is the responsibility of the University of Florida to review data received from 208 agencies and incorporate them into the data base where possible. Under the auspices of the Areawide Waste Management Group within EPA, 208 agencies and others are thus encouraged to provide UF with relevant data as they become available (in care of the authors of this report). Future work will also include statistical and loading analyses of much of the data.

SECTION IV

CRITERIA FOR DATA COLLECTION

INTRODUCTION

It is easy to be overwhelmed by the sheer magnitude of urban hydrologic and water quality data presently available. Hence, consideration must be given to the methods by which such data were collected prior to inclusion of them in a data base. On the whole, data collected directly by federal agencies (e.g., National Weather Service, U.S. Geological Survey) are gathered under standardized, documented procedures. However, the techniques used by almost all other agencies exhibit extreme variations. For instance, rainfall data may be collected using everything from a tipping bucket rain gage to a graduated cylinder read periodically. Such variations in sampling procedures may still be acceptable if they are at least documented; however, many project reports are lacking in this aspect. Since standardized procedures do exist for many phases of urban hydrologic sampling, these will be reviewed briefly, along with special considerations for different parameters.

PRECIPITATION DATA

Measurement of most meterological data is quite standardized. Publications of the National Weather Service (3) and others (4,5) describe instruments and techniques for measurement of rainfall and other pertinent variables. Accurate sampling of the time history of snowfall is seldom required; rather, the time history of snow melt is the record of concern. Hence, only measurement of rainfall is addressed here.

Most urban hydrologic models require rainfall inputs (usually intensities) at frequent time intervals (typically five minutes or less), with the required time interval decreasing as the response time of the catchment decreases, e.g., models of steep, small, impervious catchments require more frequent rainfall inputs than for flat, large, pervious ones. Eagleson and Shack (6) relate required sampling frequency to catchment and storm properties. However, some models require only hourly rainfall totals (7,8), available already tabulated from the National Weather Service for all first-order meteorological stations in the U.S. It is apparent that less frequent data can always be generated from averages of data taken at short time intervals.

Perhaps the best rain gages for this purpose are of the tipping bucket variety, in which the time of occurence of every 0.01 in. (0.25mm) of rainfall is recorded. However, by far the most common gage is the standard weighing-bucket gage used at most National Weather Service (NWS) installations. When a 24 hour chart is used on these gages, it is difficult to interpolate the chart at less than 15-minute intervals. Hence, this is often an unfortunate constraint on the temporal accuracy of rainfall data.

In the event that gages being used for modeling are only operated intermittently, antecedent conditions for rainfall may sometimes be evaluated using the nearest NWS gage, since these data are published regularly (9). The applicability of "nearby" data will depend heavily on the spatial distribution of rainfall, discussed below.

The spatial extent of the gaging network is the other critical factor. It is important, though not always essential, that at least one gage be located within the catchment under consideration. This requirement becomes more binding as the size of the catchment and the likelihood of convective rainfall (e.g., thunderstorms) increases. When, as is all too often the case, there are no gages within a catchment that may otherwise have good flow and quality measurements, the recourse is to interpolate as best as possible from nearby gages. If the rainfall is uniform in time and space (as is sometimes the case for storms of cyclonic origin), such data may adequately serve modeling needs. Quantitative methods are available for determination of the number of gages required as a function of catchment and storm characteristics (10, 11).

Point rainfall from a single gage may be converted to a spatial average using standard NWS curves (e.g., reference 5, p. 359) or more recent methods (12). Multiple-gage data averaged by the Thiessen or other techniques may create special problems, because high frequency time variations are frequently lost when station records are combined. If possible, it is preferable to input data from separate gages in a discrete manner into a model, i.e., formulate a model that is distributed enough to accept multiple rainfall inputs. Another alternative, if high frequency time variations are to be retained, is to use only one "most representative" gage for model input. In practice, the question of averaging or choice of gages is usually academic, however, since it is rare that data from more than one gage are available!

RUNOFF DATA

Quantity (runoff) measurements in urban areas are frequently difficult to perform because of a lack of an adequate hydraulic control along sewer outfalls. Almost all basic data consist of stages measured at some location, from which flows are derived, either by 1) calibration (by means of associated velocity measurements), or 2) known stage-discharge relationship (e.g., at a weir, flume or orifice constriction), or 3) theoretical stage-discharge relationship (e.g., application of Manning's equation to depth measurements in a conduit). The last of the three methods is the most common and least accurate. However, from a record of stages, users can sometimes compute their own flows, given other data on geometry and roughness. In addition, models are occasionally programmed to print out depths as well as flows, although this is uncommon. (Most data included in this report were taken by methods 1 and 2 above.)

Standardized procedures for flow measurements have been published by federal agencies (13), notably the U.S. Geological Survey (USGS) in various chapters of their *Techniques of Water Resources Investigations* and their older *Surface Water Techniques*. Useful references from this series include numbers 14-17, and most are summarized in reference 13. Survey articles are available (5, 18, 19) that describe the hydraulics of flow measurements with reference to various agency techniques.

Surveys of available techniques as applied to urban areas are also available (20-22). All measurement aspects of urban runoff studies are documented in a recent study by Wullschleger, et al. (23). For gaging installations in which surcharged conditions (full-conduit flow) are unlikely to exist, various critical depth devices are the most suitable for continuous stage monitoring, for example, flumes (22, 24, 25) or the venturi constriction used by the USGS (26). When surcharged conditions are likely or when velocity measurements are needed, instruments ranging from propeller meters to ultrasonic, doppler and electromagnetic flow meters are available (22, 23).

Most stage data are recorded continuously on various types of recorders. The majority of installations utilize recorders located at the site. A few telemeter data to a central location. In these cases, and for certain other types of recorders, the stage gages are "interrogated" at frequent time intervals (usually fractions of a minute), as opposed to production of a continuous inked line on a chart. With few exceptions, adequate temporal definition of the hydrograph is not a problem. Rather, the calibration or method used to calculate flow rates is of prime concern.

QUALITY DATA

Most quality data consist of concentrations of various parameters. Some parameters may be measured *in situ* (e.g., pH, conductivity, temperature, D.O.), but the majority must be obtained by laboratory analysis of samples of the flow. The principal consideration in the use of quality data for urban modeling is the method by which these samples are taken. Again, a prime concern is the time frame.

Many studies have been made in which a general characterization of urban runoff is required. For this purpose, composite quality samples have often been taken in which flow is withdrawn into a sample container over a relatively long period (e.g., from 15 minutes to one hour). Sometimes, in the interest of economy, composites are made for laboratory analysis from samples taken at shorter time periods. In any event, composite samples are of much less usefulness for most current urban runoff quality models, because predicted pollutograph ordinates need to be calibrated against instantaneous concentrations. (Note that concentrations, mg/l, may be readily converted to mass rates, lb/min, if the flow rate, cfs, is known.) Composited quality samples may thus be "better than nothing," but must be treated carefully if model verification is an objective.

Another aspect of sampling frequency concerns definition of first flush effects. A common practice is to sample frequently during the initial portion of a storm, and less frequently thereafter. This is accomplished by sampling frequently during the whole storm but providing laboratory analyses of only selected samples and discarding the remainder, to economize on the related expense. For example, it is common for a study to analyze three quality samples on the rising limb of the hydrograph, one near the peak and two on the hydrograph recession.

Even data that are usually termed instantaneous, may be inherently composited. This is due to the nature of automatic quality samplers, installed at many of the sampling locations. These samplers require a certain time to draw liquid into the sample jars, ranging from several seconds to several minutes depending upon the type of sampler and the volume of sample required. Larger volumes are required when a larger number of parameters is to be analyzed. Thus, some locations have quality samples withdrawn at 20-minute intervals, but the sample bottle requires ten minutes to fill. Hence, the result is ten-minute composites taken at 20-minute intervals. This is not necessarily incompatible with modeling applications, since quality predictions are sometimes averages over the time step used in the model.

Concerning selection and installation of automatic samplers themselves, recent studies have evaluated their characteristics and compared different types and makes (23, 27, 28). Manually obtained "grab samples" are also encountered frequently in the literature, especially when only a few runoff events are monitored. These may be quite acceptable if the procedure is well documented. Suggested water quality sampling procedures for various federal agencies are described in reference 13.

Few, if any, quality monitoring studies have sampled from more than one location within the cross sectional area of the flow. For the usual turbulent flow conditions, this is a reasonable practice, except for solids, in which some variation may be expected over the cross section. However, this is usually neglected.

It is very important that water quality parameters being sampled are identified exactly. Urban runoff quality sample analysis frequently requires variations from procedures given in Standard Methods (29) because of the emphasis in that text on analysis of domestic water and wastewater (23). Moreover, it is not always sufficient to state simply that analytical procedures follow those given in Standard Methods since there are frequently multiple options available for determination of a given parameter. For example, coliforms may be determined by both plate counts and membrane filters, using different growth media for either. Furthermore, the word "coliforms" by itself is ambiguous since total, fecal or other types may be implied. Another unnecessarily ambiguous parameter is phosphorous, since it is frequently measured as total P, phosphate, ortho-phosphate, hydrolizable P, organic P, etc. and may also be given as only the dissolved fraction.

As important as the parameter itself and type of sample (e.g., total, dissolved, fixed) are the units associated with the parameter. Again, phosphorus is a frequent culprit, in which a three-fold difference results from listing a concentration as mg/l as P versus mg/l as PO_4.

A relatively unambiguous parameter identification may be achieved by the assignment of a STORET code to each parameter. "STORET" is the acronym describing EPA's Water Quality Control Information System (30). Units are clearly specified as are many analytical methods and types of sample. Water quality parameters and their STORET codes encountered during this study are given in Section VI.

COMPREHENSIVE EXAMPLES

Wullschleger et al. (23) have prepared an excellent review and procedural guide as to all aspects of urban runoff sampling. In addition, a briefer review is provided by Lager and Smith (31) and the USGS (13). Flow measurement techniques are well covered by Shelley and Kirkpatrick (22). Case studies may be consulted for useful background information (e.g., 32-35).

TIME SYNCHRONIZATION

The fundamental model verification data are the rainfall-runoff-quality measurements discussed above. Of considerable importance is the relative time of each sample. Ideally, rainfall and runoff are recorded on the same chart (typical of USGS installations) and a mark is also made on the chart when the automatic quality sampler is switched on. This provides absolute timing on a relative scale, even if the chart is not synchronized perfectly with the time of day.

At many locations, however, isolated rain gages are used. In the absence of telemetry to a central location, the temporal correlation of rainfalls and flow rates may be questionable. One solution to this problem may result from the use of the models themselves in which predicted and measured hydrographs may differ only by a constant time shift. This time shift may then be considered as the necessary adjustment between the clocks of the rain gages and the flow recorder.

MODELING DATA

Data required for models run the gamut from generalized demographic, land use and meteorological data to the details of sewer conduit geometries, slopes, etc. Such data are nearly always available from the city or municipality or other source, but it is of great usefulness if it has been gathered already by a group interested in applying models. Thus, even though different models will require different levels of detail, most will draw upon the same basic set of input requirements, e.g., topography, land use and soil parameters, demographic data, meteorology, drainage definition, and treatment, storage and cost descriptions.

Where possible, input data suitable for urban runoff models have been collected as part of this study where such data have already been prepared as part of other studies. For all cases, attempts are being made to obtain the relevant basic data mentioned earlier. In several instances, however, it is necessary to contact the data-collecting agency or municipality directly for the required input information.

SECTION V

DATA SOURCES

INTRODUCTION

A typical conclusion in many reports related to urban hydrology is that "more data are needed." It is not always clear what purposes additional data will serve, but the attitude is almost inevitably, "the more data, the better." In spite of this generality, it has been observed during the course of this study that vast amounts of rainfall-runoff-quality data already exist, and even more are currently being collected. Of course, only a minority of these data are suitable for purposes such as modeling, although a larger fraction may be useful from the characterization viewpoint. An even smaller fraction are actually accessible in a well documented, tabulated fashion. Finally, many sources, especially university studies, are only discovered by accident; no clearinghouse for such studies exists.

Still, many data sources have been uncovered during the course of this study and new ones continue to arrive. Only the ones considered most promising from a modeling viewpoint are given herein, and it is regrettable that suitable sources have probably been omitted through oversight. It is the purpose of this section to describe past and present summaries and sources of urban runoff data and to describe specific sites for which promising data exist but which were omitted from the data base prepared during this study for various reasons. Sections VII and VIII describe in detail data sources included in the data base itself.

PUBLISHED DATA SUMMARIES

American Society of Civil Engineers

The ASCE Urban Water Resources Research Council has conducted relevant studies of urban hydrology since 1967. Among the most widely used rainfall-runoff data are those collected at the Northwood catchment in Baltimore (36) and the Oakdale catchment in Chicago (37) and published under ASCE auspices. Later summaries by Tucker on monitored rainfall (38, 39) and other urban rainfall-runoff data (40, 41, 42) remain the only conveniently published information for many catchments, including some included in this report. Thus, references 36,37, 40, 41, and 42 should still be considered as prime data sources.

Other recent ASCE publications include modeling applications (43) and a summary of activities of the Council (44). Recent NSF-sponsored work has produced summaries of available urban hydrologic data and modeling activities in the U.S. (45), Australia (46), Canada (47), the United Kingdom (48), West Germany (148), Sweden (149), France (150), Norway (151), The Netherlands (180) and Poland (181). McPherson's report (45) contains a summary of U.S. and other catchments that have actually been used for testing of several current urban hydrologic models.

Illinois State Water Survey

During 1971 the Illinois State Water Survey evaluated the capabilities of the British Road Research Laboratory (RRL) model for use in urban drainage design (49). This study included testing on ten U.S. catchments. The Survey later extended the capabilities of the RRL model to create the Illinois Urban Drainage Area Simulator (ILLUDAS) model (50). For this study, ILLUDAS was tested on rainfall-runoff data from 23 different catchments, all of which are described by Terstriep and Stall (50). The 23 include nine from the RRL study, and the report (50) provides very useful capsulized information about each catchment.

U.S. Geological Survey

The USGS has collected many of the data currently available for urban basins, and their urban hydrology programs are continuing. Several of the data sources utilized in the ILLUDAS study (50), for instance, were from the USGS. Current (1976), detailed sampling of urban rainfall-runoff-quality is being conducted in Denver, Philadelphia and Broward County, Florida. (The latter site is included in this report.) The main difficulty in utilizing USGS data is in obtaining published references to the studies. The extensive Catalogue of Information on Water Data (51), published biannually, apparently only contains references to continuing stream, lake, etc. gaging programs. Schneider's 1968 survey (52) contains some information, but is dated. A survey by the Water Resources Scientific Information Center (53) contains references to USGS urban hydrology studies as well as others. However, direct inquiries can be made to state USGS offices for information on relevant studies. In addition, most USGS quality data are placed in the EPA STORET file or the Water Data Information and Retrieval System (WATSTORE) file of the USGS itself (54) and are thus fairly easily accessible. Finally, the USGS has also established its National Water Data Exchange (NAWDEX), whose purpose is to point users to relevant data files in the manner of a clearinghouse (55).

Office of Water Resources Technology

The OWRT has sponsored several projects related to urban hydrology and data collection. Included among them have been recent studies at Rutgers, Cornell, Virginia Polytechnic Institute, University of Maryland and University of Massachusetts. Final reports from these studies are forthcoming. Data from one OWRT-sponsored study in Lincoln, Nebraska (56) are included in this report.

Environmental Protection Agency

Under the EPA and its predecessors (PHS, FWPCA, FWQA) many urban runoff studies have been conducted involving extensive sampling programs, some of which are included in this report. Although better documented than most studies, many of the earlier reports contain samples of only a few storms at several sites or rely upon composited samples, thus making them unsuitable for modeling applications. Such reports may still contain useful characterization data, however, and several are utilized for this purpose by Heaney et al. (57).

The number of potentially useful EPA-sponsored studies is too large to list each individually in this report. Also, the number is increasing because of EPA Section 201 Construction Grant and Section 208 Areawide Waste Management Grant studies currently in progress under the 1972 Amendments to the Federal Water Pollution Control Act. However, reference to some reports is made in subsequent sections.

Other Agencies

Other federal agencies also publish hydrologic data, but few data are specifically for urban applications. For example, the Agricultural Research Service (ARS) has published rainfall-runoff data for many agricultural watersheds (58) that are useful for hydrologic modeling in general. The National Weather Service (NWS), Office of Hydrology, has compiled some data for use in their river forecasting and modeling efforts, but engage in little or no acquisition themselves. Of course, the NWS through its National Climatic Center at Asheville, North Carolina is the prime source of precipitation and other meteorological data collected at NWS and some other installations. For instance, although precipitation data are routinely reduced only at hourly intervals, photocopies of the original weighing bucket charts may be obtained from which data may be reduced at finer time intervals. In addition, the parent arm of the NWS, the National Oceanic and Atmospheric Administration (NOAA), has established their ENDEX/OASIS data retrieval system for access to environmental-related data within their jurisdiction (59). However, the emphasis is upon marine data.

The Hydrologic Engineering Center (HEC) of the Corps of Engineers engages in extensive model development activities (e.g., 7) but few data collection activities. However, they have sponsored urban runoff monitoring in the San Francisco Bay region (160), which is listed in Table V-1 to follow.

References to other available hydrologic data, (though not necessarily urban), may be found in many reports, theses, dissertations, papers, etc. A report prepared as part of the International Hydrological Decade (60) contains information on 60 experimental watersheds in the U.S., but few are urban in character. A report prepared by the National Technical Information Service (NTIS) on data files available from federal agencies (61) contains only one reference to hydrologic data (to test data included with the NWS Office of Hydrology river forecast models).

DATA SOURCES IN OTHER COUNTRIES

Programs in urban hydrology in several countries have been summarized by the ASCE as discussed previously (45-48, 148-151, 180, 181). Several Canadian studies are referenced in subsequent sections of this report, and data from

Windsor, Ontario are included in the data base. A summary of current activities related to urban runoff in the Great Lakes region is available (152). Another recent publication provides a useful review of available snow quality data for urban areas (62).

As additional sources to the ASCE report on Australia (46), Heeps and Mein (153) describe rainfall-runoff monitoring in Canbera and Melbourne, and Cordery (154) describes quality measurements in Sydney. Reports on urban runoff measurements in Paris (155) and Munich (156) have also been published. Additional references to monitored West German catchments may be found in other model studies (126, 174). Lindh (149) discusses data for the Bergsjön catchment near Gothenberg, Sweden. Rainfall-runoff data for this catchment may be found in reports published by Arnell and Lyngfelt (157, 158).

POTENTIAL DATA SOURCES NOT INCLUDED IN FIRST RELEASE OF DATA BASE

During the course of this study, many promising data sources were uncovered, but only a portion are included in this first release of the data base. These locations are described in detail in Sections VII and VIII. Other locations showing promise as to modeling data are listed in Table V-1 with related information. Some sources will probably be included in future addenda to this report as data are reduced or computerized for inclusion. Some sources are definitely deserving of inclusion, but were simply not available in time. Note that the vast number of sources owing to EPA 201 and 208 studies are generally *not* included in Table V-1, as these studies are either being initiated or have been underway for too short a period to obtain and reduce useful data. Moreover, little is known about most of them except at the local level. However, as these sources become viable and provide data to the University of Florida, they will be included in future addenda.

Table V-1. Potential Sources of Data Not Included in First Release of Data Base

City, Catchment, and Major Land Use	Area ac(ha)	Drainage Systems	Reasons for Exclusion	Quantity Data(Years)	Flow Meas. Technique	Quality Data(Years)	Contact	References
Atlanta, GA								
Confederate Ave (Res.)	1129(457)	C	I_3, I_4	r_2, (69,73)	f_8, f_2	q_4, (69,73)	1,2	63,64
Boulevard(Res.)	2421(980)	C	I_3, I_4	r_2, (69,73)	f_8, f_2	q_4, (69,73)		
McDaniel St.(Res.)	969(392)	C	I_3, I_4	r_2, (69,73)	f_8, f_2	q_2, (69,73)		
Norlan Dr.(Res.)	954(386)	S	I_3, I_4	r_1, (69)	f_8	q_1, (69)		
Camplan St.(Res.)	517(209)	S	I_3, I_4	r_2, (69)	f_8	q_2, (69)		
Fed. Prison(Open)	1490(606)	S	I_3, I_4	r_1, (69)	f_8	q_1, (69)		
Burlington, ONT								
Malvern(Res.)	57.6(23.3)	S	I_2	r_3, (73-75)	f_2	q_4, (73-71)	3	62,66,67
Commercial	17.0(6.9)	S	I_2	r_3, (74-75)	f_2	q_4, (74-75)		
Cincinnati, OH								
Bloody Run(Res.)	2380(964)	C	I_4	r_2, (70)	f_1, f_2	q_3, (70)	4	68,102,129 40,50,66
Mt. Washington(Res.)	27(11)	S	I_5	r_2, (62-64)	f_2	q_1, (62-63)		
Cleveland, OH								
Madison(Res.)	2550(1030)	C	I_1, I_2, I_3	r_1, (66-67)	f_1	q_1, (66-67)	5	70
Edgewater(Res.)	1840(745)	S	I_1, I_2, I_3	r_1, (66-67)	f_2	q_1, (66-67)		
Denver, CO								
Several residential		S	I_1, I_2	r_1, (69-date)	f_1, f_2, f_6	q_5	6	42,71,72
Des Moines, IA								
Several residential		CSS	I_3	r_1, (69)	f_2	q_1, (69)	7	73

Table V-1. (continued)

City, Catchment, and Major Land Use	Area ac(ha)	Drainage Systems	Reasons for Inclusion	Quantity Data(Years)	Flow Meas. Technique	Quality Data(Years)	Contact	References
Detroit, MI Oakwood(Res.)	1500(607)	C	l_1,l_2,l_3	r_2,(74-date)	f_7	q_5	8	42, 130, 170
Greenfield, MA Maple Brook(Res.)	547(221)	S	l_2	r_1,(74-75)	f_2	q_1,(74-75)	9	74
Halifax, N.S. Quinpool Rd.(Com.) Cambridge St.(Res.) Total area	 1.0(0.4) 2.4(1.0) 168(68)	 C^a C^a C^a	 l_3 l_3 l_3	 r_1,(69-70) r_1,(69-70) r_1,(69-70)	 f_2 f_2 f_4	 q_1,(69-70) q_1,(69-70) q_1,(69-70)	10	75,76,77, 78
Hamilton, ONT Hamilton Mt.(Res.)	176(71)	C	l_2	r_1,(75-76)	f_2	q_2,(75-76)	11	79
Houston, TX Woodlands(Res.)	multiple sites	S	l_3	r_3,(73-76)	f_8	q_4,(73-76)	12	80, 169
Other Houston		S	l_1	r_2,(55-69)		q_5	13	41,42,50, 164-168
Kingston, ONT Calvin Park(Res.)	36(15)	S	l_5	r_2,(73-74)	f_2	None	14	67,81,82
Lafayette, IN Multiple sites		S	l_1,l_3,l_5	r_1,(74-75)		q_5	15	42, 161
Louisville, KY Multiple sites		S	l_1,l_5	r_1,(45-47)	f_8	None	16	52,83,84

[a] Surface runoff samples taken.

City, Catchment, and Major Land Use	Area ac(ha)	Drainage Systems	Reasons for Exclusion	Quantity Data(Years)	Flow Meas. Technique	Quality Data(Years)	Contact	References
Lubbock, TX							17	85
Clapp Park(Res.)	223(90.2)	S	I_5	r_2, (71–72)	f_3	q_6, (71–72)		
Milwaukee, WI							18	32, 41, 162
Humboldt Ave.(Res.)	570(231)	C	I_3, I_4	r_3, (71–72)	f_2, f_8	q_6, (71–75)		
Occoquan Watershed, VA							19	86
Several Urban		S	I_5	r_3, (74–date)	f_2, f_8	q_6, (74–date)		
Orlando, FL							20	87, 88, 89
Lake Eola(Com.)	28(11.3)	S	I_1, I_6	r_1, (73–74)	f_1	q_1, (73–74)		
Lake Eola(Res.)	16(6.5)	S	I_2, I_6	r_1, (73–74)	f_1	q_1, (73–74)		
Richmond, VA							21	
Multiple Sites		S	I_2			q_5		
Rochester, NY							22	
Multiple sites		C,S	I_1, I_2, I_3	r_3, (74–76)	f_2, f_9	q_6, (74–76)		147, 173
Salt Lake City, UT							23	159
Layton(Hwy.)	1.35(0.54)	S^a	I_5	r_3, (72–73)	f_6	None		
[illegible](Hwy.)	0.54(0.22)	S^a	I_5	r_3, (72–73)	f_6	None		

[a] Open channel, roadside drainage.

Table V-1 (continued)

City, Catchment, and Major Land Use	Area ac(ha)	Drainage System	Reasons for Exclusion	Quantity Data(Years)	Flow Meas. Technique	Quality Data(Years)	Contact	References
San Francisco Bay, CA							24	160
Castro Valley[Hayward] (Res.)	3200(1300)	S	l_5	r_3,(72–76)	f_2	q_4,(72–76)		
Peralta Cr. [Oakland] (Res.)	1290(520)	S	l_5	r_1,(73)	f_2	q_2,(73)		
Ross Cr.[San Jose] (Res.)	4400(1810)	S	l_5	r_1,(73–74)	f_2	q_2,(73–74)		
Strong Ranch Sl. [Sacramento] (Res.)	3200(1300)	S	l_5	r_3,(73–76)	f_2	q_4,(73–76)		
Syracuse, NY							22	147
[illegible] St.(Com.)	135(54.6)	C	l_1,l_3	r_3,(73–76)	f_2	q_4,(73–76)		
Newell St.(Res.)	54(21.9)	C	l_1,l_3	r_3,(73–76)	f_2	q_4,(73–76)		
Tallahassee, FL							25	90
Magnolia Ave(Res.)	1780(721)	S	l_1,l_3, l_5,l_8	r_3,(74–75)	f_8	q_4,(74–75)		
Toronto, ONT								
North York, Brucewood (Res.)	48.3(19.5)	S	l_1,l_2,l_5	r_3,(74–75)	f_2	q_4,(74–75)	3	62,92–93
East York(Res.)	383(155)	C	l_1,l_1,l_2,l_3	r_2,(76)	f_2	q_2,(76)	27	62,94
Int. Airport	495(200)	S	l_1,l_3	r_1,(74–75)	f_1	q_1,(74–75)	26	62,95
West Toronto(Res.)	2332(943)	C	l_1,l_4	r_3,(68–75)	f_2	None	28	62,63

Table V-4 (concluded)

City, Catchment, and Major Land Use	Area ac(ha)	Drainage Systems	Reasons for Exclusion	Quantity Data(Years)	Flow Meas. Technique	Quality Data(Years)	Contact	References
Tucson, AZ Multiple sites		S	l_3	r_3,(67–75)	f_3	q_6,(67–75)	29	96–99
Washington, DC Kingman Lake(Res.)	4200(1700)	C	l_3,l_6	r_3,(69)	f_1	q_1,(69)	30	100,102
Winnipeg, MAN Bannatyne(Com.)	542(219)	C	l_3,l_6	r_3,(69–71)	f_2	q_1,(69–71)	31	62,63

Notes for Table V-1

Codes--

f_1	Stage measurement in conduits converted to flow using Manning equation
f_2	Weir
f_3	Parshall flume
f_4	Other critical depth measurement
f_5	Dye dilution
f_6	Calibrated flow constriction
f_7	Pumping records
f_8	Stage discharge calibration
f_9	Flow meter
i_1	Lack of sufficient documentation
i_2	Program being initiated or too few data to date
i_3	Data not in suitable form for transmittal or further reduction required
i_4	Data questionable or requiring re-analysis
i_5	Data unavailabe to UF in time
i_6	Large sampling interval, portions missing, or unsuitable for modeling
q_1	Yes, few parameters, < 10 storms
q_2	Yes, several parameters, < 10 storms
q_3	Yes, few parameters, > 10 storms
q_4	Yes, several parameters, > 10 storms
q_5	Program being initiated
r_1	Yes, < 10 storms
r_2	Yes, 10-20 storms
r_3	Yes, > 20 storms
C	Combined sewer systems
S	Storm sewer and/or natural drainage system.

Notes for Table V-1 (continued)

Contacts--

1. Mr. Allen Fields, Environment and Streets, City of Atlanta, City Hall, Atlanta, Georgia 30303.

2. Black, Crow & Eidsness, Inc., Consulting Engineers, 1261 Spring St. NW, Atlanta, Georgia 30309.

3. Mr. J. Marsalek, Hydraulics Research Division, Canada Centre for Inland Waters, Box 5050, Burlington, Ontario L7R 4A6.

4. Dr. H.C. Preul, Dept. of Civil Engineering, University of Cincinnati, Cincinnati, Ohio 45221.

5. Mr. L.W. Curtis, Havens and Emerson, Ltd., 1220 Leader Bldg., Cleveland, Ohio 44114.

6. Mr. J. Biesecker, District Chief, U.S. Geological Survey, Water Resources Division, Stop 415, Box 25046, Denver Federal Center, Denver, Colorado 80225.

7. Henningson, Durham and Richardson, Inc., 8404 Indian Hills Drive, Omaha, Nebraska 68114.

8. Mr. D. Suhrv, Director of Engineering, Detroit Metro Water Department, Water Board Bldg., Detroit, Michigan 48226.

9. Dr. D.D. Adrian, Dept. of Civil Engineering, University of Massachusetts, Amherst, Massachusetts 01002.

10. Dr. D.H. Waller, Dept. of Civil Engineering, Nova Scotia Technical University, Box 1000, Halifax, Nova Scotia.

11. Mr. C.W. Eicher, Gore and Storrie, Ltd., 1670 Bayview Avenue, Toronto, Ontario M4G 3C2.

12. Dr. W. Characklis, Dept. of Environmental Science and Engineering, Rice University, Houston, Texas 77001.

13. U.S. Geological Survey, Water Resources Division, 2320 La Branch St., Room 1112, Houston, Texas 77004.

14. Dr. W.E. Watt, Dept. of Civil Engineering, Queen's University, Kingston, Ontario K7L 3N6.

15. Dr. A. Rao, Dept. of Civil Engineering, Purdue University, Lafayette, Indiana 47907.

16. District Engineer, U.S. Army Engineer District, Louisville, 600 Federal Plaza, Box 59, Louisville, Kentucky 40201.

17. Dr. D. Wells, Water Resources Center, Texas Tech University, Lubbock, Texas 79409.

18. City of Milwaukee, Dept. of Public Works, Milwaukee, Wisconsin 53202.

19. Dr. T. Grizzard, Laboratory Director, Occoquan Watershed Monitoring Laboratory, Virginia Polytechnic Institute, Box 773, Manassas, Virginia 22110.

20. Dr. M. Wanielista, College of Engineering, Florida Technological University, Box 25000, Orlando, Florida 32816.

21. Mr. K.C. Das, Director, Division of Special Projects, Piedmont Regional Office, State Water Control Board, Box 11143, Richmond, Virginia 23230.

22. Mr. D. Carleo, O'Brien & Gere Engineers, 1304 Buckley Rd., Syracuse, New York 13201.

23. Utah Water Research Laboratory, Utah State University, Logan, Utah 84322.

24. Mr. Bill S. Eichert, Director, The Hydrologic Engineering Center, Corps of Engineers, 609 2nd St., Davis, California 95616.

25. Dr. R.C. Harriss, Dept. of Oceanography, Florida State University, Tallahassee, Florida 32306.

26. Dr. P.E. Wisner, James F. MacLaren Ltd., 435 McNicoll Ave., Willowdale, Ontario M2H 2R8.

27. Mr. E. Larsen, M.M. Dillon Ltd., 50 Holly St., Toronto, Ontario M4S 2E9.

28. Mr. C.S. Kitchen, Data Retrieval and Reporting, Dept. of Public Works, 24th Floor, East Tower, City Hall, Toronto, Ontario M5H 2N2.

29. Dr. S. Resnick, University of Arizona, Water Resources Research Center, Bldg. No. 28, Tucson, Arizona 85721.

30. Roy F. Weston, Inc., Weston Way, West Chester, Pennsylvania 19380.

31. Mr. G.E. Burns, Manager of Engineering, Waterworks, Waste and Disposal Division, City of Winnipeg, 455 Ellice Ave., Winnipeg, Manitoba R3B 1Y6.

SECTION VI

DATA BASE FORMAT

TYPES OF INFORMATION

At least four types of information are potentially available for each location utilized as a data source:

1. physical, demographic, etc. descriptions of the sites, plus maps, parameters and sampling methods;

2. published reports and other written documentation;

3. the rainfall-runoff-quality data themselves; and

4. associated modeling data, e.g., maps, plans, photos, etc.

Sections VII and VIII contain item 1 in write-ups for each location. A standardized tabular format is used for all sites. Item 2 is handled through a list of references for each location. Item 3 is handled separately, wherein all data have been coded and placed on a magnetic tape, the format of which is explained below. UF has been able to obtain a limited amount of data needed for model input, item 4. These will be available for short-term loan. The remainder of such data will have to be obtained from contacts with individuals at each location. In addition, input data for the EPA Storm Water Management Model, SWMM (101-103) are available for a few locations.

DATA IDENTIFICATION

Location Identification

For computer coding, all locations are given a state, city and catchment code. State codes are the standard two-character mnemonics used by the Postal Service. These are listed in Table VI-1. Canadian provinces are identified in the same manner, as given in Table VI-1. Since each mnemonic must be unique, the most logical two-character provincial identifier is not always used in order to avoid conflicts with state mnemonics.

A two-digit numeric code is arbitrarily assigned to each data location within a state. Similarly, a two-digit numeric code is then assigned to each catchment at a given location. These numbers have been assigned strictly on the basis of the order in which each location has been processed for the data base. They are identified along with each description, in Sections VII and VIII. An index is provided in Table VI-2.

Table VI-1. State and Provincial Mnemonics

Area	Mnemonic	Area	Mnemonic
Alabama	AL	Nevada	NV
Alaska	AK	New Brunswick	NK
Alberta	AB	Newfoundland	NF
Arizona	AZ	New Hampshire	NH
Arkansas	AR	New Jersey	NJ
British Columbia	BC	New Mexico	NM
California	CA	New York	NY
Colorado	CO	North Carolina	NC
Connecticut	CT	Nova Scotia	NS
Delaware	DE	Ohio	OH
District of Columbia	DC	Oklahoma	OK
Florida	FL	Ontario	ON
Georgia	GA	Oregon	OR
Hawaii	HI	Pennsylvania	PA
Idaho	ID	Prince Edward Island	PI
Illinois	IL	Puerto Rico	PR
Indiana	IN	Quebec	PQ
Iowa	IA	Rhode Island	RI
Kansas	KS	Saskatchewan	SS
Kentucky	KY	South Carolina	SC
Louisiana	LA	South Dakota	SD
Maine	ME	Tennessee	TN
Manitoba	MB	Texas	TX
Maryland	MD	Utah	UT
Massachusetts	MA	Vermont	VT
Michigan	MI	Virginia	VA
Minnesota	MN	Virgin Islands	VI
Mississippi	MS	Washington	WA
Missouri	MO	West Virginia	WV
Montana	MT	Wisconsin	WI
Nebraska	NB	Wyoming	WY

Table VII-2 Index to Location ID Codes

Code	State	City	Catchment
CA 1 1	California	San Francisco	Baker St.
CA 1 2			Mariposa St.
CA 1 3			Brotherhood Way
CA 1 4			Vicente St., N.
CA 1 5			Vicente, St., S.
CA 1 6			Selby St.
CA 1 7			Laguna St.
CA 2 1	California	Los Angeles	Echo Park
FL 1 1	Florida	Broward County	Residential
FL 1 2			Transportation
FL 1 3			Commercial
IL 1 1	Illinois	Chicago	Oakdale
IL 2 1	Illinois	Champaign-Urbana	Boneyard Creek
KS 1 1	Kansas	Wichita	Dry Creek
MD 1 1	Maryland	Baltimore	Gray Haven
MD 1 2			Northwood
MS 1 1	Mississippi	Jackson	Crane Creek
NB 1 1	Nebraska	Lincoln	39 & Holdrege
NB 1 2			63 & Holdrege
NB 1 3			78 & A
NC 2 1	North Carolina	Winston-Salem	Tar Branch
NC 1 1	North Carolina	Durham	Third Fork
NY 1 1	New York	Westbury	Woodoak Dr.
OH 1 1	Ohio	Bucyrus	Sewer District 8
ON 1 1	Ontario	Windsor	Labadie Rd.
OR 1 1	Oregon	Portland	Eastmoreland
PA 1 1	Pennsylvania	Lancaster	Stevens Ave.
PA 2 1	Pennsylvania	Philadelphia	Wingohocking

Table VI-2 (concluded)

Code	State	City	Catchment
TX 1 1	Texas	Houston	Hunting Bayou (Cavalcade St.)
TX 1 2			Hunting Bayou (Falls St.)
TX 1 3			Bering Ditch
TX 1 4			Berry Creek
VA 1 1	Virginia	Falls Church	Tripps Run
WA 1 1	Washington	Seattle	View Ridge 1
WA 1 2			View Ridge 2
WA 1 3			South Seattle
WA 1 4			Southcenter
WA 1 5			Lake Hills
WA 1 6			Highlands
WA 1 7			Cent. Bus. Dist.
WI 1 1	Wisconsin	Racine	Site 1

Parameter Identification

Each quantity and quality parameter is identified with its appropriate five-digit STORET code (30). Where these codes are missing, arbitrary codes have been assigned by UF. These are in the 90000 range so as to avoid conflict with STORET codes which go no higher than the 80000 range. All codes for parameters encountered during the processing of data are given in Table VI-3 with the units used. As discussed previously, in most cases, STORET codes have the advantage of implying the units, type of sample (e.g., total, fixed, dissolved) and analytical technique used. Slight variances with STORET definitions are indicated in Table VI-3. A complete list of STORET codes may be found in the STORET manual (30).

CODING FORMAT

All data have been placed on standard punched cards for later entry onto magnetic tapes. Each card contains the location ID followed by the date, time and up to five parameters, as shown in Figure VI-1. Although this format is far from being compressed, it does allow easy identification and filing of each card. Also, new data may easily be added to a given location. Decimal points are always punched, and no scaling is performed. All values are instantaneous values at the indicated time except for rainfall, for which the value given is an average intensity over the time interval beginning at the indicated time. In a few instances, cumulative rainfall depth is given to avoid calculation of intensities over varying time intervals.

Coliforms and streptococci are treated differently because their range (1 to 10^8) is greater than the seven-character field width of the format used for data entries. Hence, all such data are entered on the cards as $100 \cdot \log_{10}$ (MPN/100ml). (The multiplier of 100 is used to provide extra significant figures when an F7.2 format is used.) Users should be careful to remember this fact when reading values of these parameters.

A typical grouping of punched data is shown in Figure VI-2. Note that a header card containing the name of city, state and catchment precedes the data for that catchment. All data from one storm event are grouped together, although rainfall, flow and quality cards may appear in a different order for different catchments. Occasionally, as in Seattle, a few storm parameters (e.g., dry days, total depth) may precede the storm data itself.

ACCESS AND USE

The emphasis of this project was not upon formulation of a sophisticated storage and retrieval system for management of the data base. Rather, it was to obtain and document as much data as possible. Hence, the "data base" itself is merely a magnetic tape containing card images of the type shown in Figure VI-2. On the tape, data are blocked according to cities, as sketched in Figure VI-3. The first block contains information on STORET codes and card format, and material accompanying the tape explains the location (block number) of data for each city.

Table VI-1.STORET and University of Florida Parameter Codes.

Note: Codes above 90000 assigned by UF

Code	Parameter and Units	Chemical Symbol or Abbreviation
10	Temperature, [°C]	
11	Temperature, [°F]	
45	Precipitation, total, [in./day or in./storm^a]	
53	Catchment area, [acres]	
61	Flow, instantaneous stream or conduit^b, [ft^3/sec = cfs]	
65	Stage, [ft]	
70	Turbidity, [Jackson Turbidity Units = JTU]	
80	Color, [Platinum Cobalt Units = PCU]	
94	Conductivity, field [micro mhos = µmho]	
95	Conductivity, at 25°C [µmho]	
299	Oxygen, dissolved, by probe, [mg/l]	
300	Oxygen, dissolved, [mg/l]	DO
301	Oxygen, dissolved, [% saturation]	DO
310	Biochemical oxygen demand, 5-day, [mg/l]	DO
311	Biochemical oxygen demand, 5-day, dissolved, [mg/l]	BOD_5
324	Biochemical oxygen demand, 20-day, [mg/l]	Diss. BOD_5
340	Chemical oxygen demand, high level, [mg/l]	BOD_{20}
341	Chemical oxygen demand, dissolved [mg/l]	COD
400	pH	Diss. COD
405	Carbon dioxide, [mg/l as CO_2]	
410	Alkalinity, total, [mg/l as Ca CO_3]	CO_2
440	Bicarbonate ion, [mg/l as HCO_3]	
445	Carbonate ion, [mg/l as CO_3]	CO_3

Table VI-3(continued)

Code	Parameter and Units	Chemical Symbol or Abbreviation
480	Salinity, [parts per thousand = ppt]	
500	Residue, total, (total solids), [mg/l]	TS
505	Residue, total volatile (total volatile solids), [mg/l]	TVS
515	Residue, total filterable, (total dissolved solids), [mg/l]	TDS
530	Residue, total nonfilterable, (t[illegible]l suspended sol'ds),[mg/l]	TSS or SS
535	Residue, volatile nonfilterable ([illegible]atile suspended solids), [mg/l]	VSS
540	Residue, fixed nonfilterable (fixed suspended solids), [mg/l]	FSS
544	Residue, volatile settleable (volatile settleable solids), at 45 min[c], [mg/l]	
545	Residue, settleable (settleable solids) at 45 min[c], [ml/l]	Set. S
546	Residue, settleable (settleable solids) at 45 min[c], [mg/l]	Set. S
600	Nitrogen, total, [mg/l as N]	Tot. N
605	Nitrogen, total organic, [mg/l as N]	Org. N
610	Nitrogen, total ammonia, [mg/l as N]	NH_3-N
615	Nitrite nitrogen, total, [mg/l as N]	NO_2-N
620	Nitrate nitrogen, total, [mg/l as N]	NO_3-N
625	Nitrogen, total Kjeldahl, [mg/l as N]	TKN
630	Nitrite plus nitrate, total (one determination), [mg/l as N]	NO_2-N+NO_3-N
650	Phosphate, total, [mg/l as PO_4]	TPO_4-PO_4
653	Phosphate, total soluble, [mg/l as PO_4]	TPO_4-PO_4(sol)
660	Orthophosphate, total, [mg/l as PO_4]	OPO_4-PO_4
665	Phosphorus, total (wet method), [mg/l as P]	Tot. P
666	Phosphorus, dissolved (wet method), [mg/l as P]	Dis. P
669	Phosphorus, total hydrolyzable, [mg/l as P]	Tot. hyd-P

Table VI-3 (continued)

Code	Parameter and Units	Chemical Symbol or Abbreviation
671	Orthophosphate, dissolved, [mg/l as P]	OPO_4-P(sol.)
680	Carbon, total organic, [mg/l as C]	TOC
685	Carbon, total inorganic, [mg/l as C]	
690	Carbon, total [mg/l as C]	Tot. C
902	Hardness, carbonate, [mg/l as $CaCO_3$]	
916	Calcium, total, [mg/l as Ca]	Ca
927	Magnesium, total, [mg/l as Mg]	Mg
929	Sodium, total, [mg/l as Na]	Na
937	Potassium, total, [mg/l as K]	K
940	Chloride, [mg/l as Cl]	Cl
945	Sulfate, [mg/l as SO_4]	SO_4
955	Silica, dissolved, [mg/l as SiO_2]	SiO_2(soluble)
1002	Arsenic, total, [ug/l as As]	As
1027	Cadmium, total, [ug/l as Cd]	Cd
1034	Chromium, total, [ug/l as Cr]	Cr
1037	Cobalt, total, [mg/l as Co]	Co
1041	Copper, suspended, [ug/l as Cu]	Cu(susp.)
1042	Copper, total, [ug/l as Cu]	Cu
1045	Iron, total, [ug/l as Fe]	Fe
1051	Lead, total, [ug/l as Pb]	Pb
1055	Manganese, total [mg/l as Mn]	Mn
1067	Nickel, total, [mg/l as Ni]	Ni
1082	Strontium, total, [mg/l as Sr]	Sr

Table VI-3(continued)

Code	Parameter and Units	Chemical Symbol or Abbreviation
1092	Zinc, total, [ug/l as Zn]	Zn
1107	Aluminum, total, [mg/l as Al]	Al
31501	Coliform, tot., membrane filt., immed., M-endo. media,35°C,[MPN/100ml]^d	Tot. Colif.
31503	Coliform, tot., membrane filt., delayed, M-endo.media,35°C,[MPN/100ml]^d	Tot. Colif.
31504	Coliform, tot., membrane filt., immed., Les endo. agar,35°C,[MPN/100ml]^d	Tot. Colif.
31505	Coliform, tot., MPN, confirmed test, 35°C, [MPN/100ml]^d	Tot. Colif.
31615	Coliform, fecal, MPN, Ec. media, 44.5°C, [MPN/100ml]^d	Fec. Colif.
31616	Coliform, fecal, membrane filt., M-fc. broth, 44.5°C, [MPN/100ml]^d	Fec. Colif.
31679	Streptococci, fecal, [MPN/100ml]^d	Fec. Strep.
50055	Depth of flow in pipe or conduit, [in.]	
70299	Solids, suspended by evaporation at 180°C, [mg/l]	TSS or SS
70351	Grease, hexane-soluble, [mg/l]	
70507	Orthophosphate, total, [mg/l as P]	OPO_4-P
71886	Phosphorus, total, [mg/l as PO_4]	Tot. P-PO_4
71887	Nitrogen, total, [mg/l as NO_3]	Tot. N-NO_3
71889	Orthophosphate, soluble, [mg/l as PO_4]	OPO_4-PO_4(sol)
71900	Mercury, total, [ug/l as Hg]	Hg
90035	Cumulative rainfall at given time, (in.) sixth page	
90036	Cumulative rainfall at given time, (in.) fifth page	
90037	Cumulative rainfall at given time, (in.) fourth page	
90038	Cumulative rainfall at given time, (in.) third page	
90039	Cumulative rainfall at given time, (in.) second page	
90045	Rainfall intensity, beginning at indicated time,[in./hr], sixth page	

Table VI-3(continued)

Code	Parameter and Units	Chemical Symbol or Abbreviation
90046	Rainfall intensity, beginning at indicated time,[in./hr], fifth gage	
90047	Rainfall intensity, beginning at indicated time,[in./hr], fourth gage	
90048	Rainfall intensity, beginning at indicated time,[in./hr], third gage	
90049	Rainfall intensity, beginning at indicated time,[in./hr], second gage	
90050	Rainfall intensity, beginning at indicated time,[in./hr], principal gage	
90051	Storm duration, [min]	
90052	Minimum flow, lower bound when flow reported only over a range, [cfs]	
90053	Maximum flow, upper bound when flow reported only over a range, [cfs]	
90055[c]	Floatables, [mg/l]	
90060	Residue, settleable (settleable solids) at 30 min, [ml/l]	Set. S
90063	Settled COD, [mg/l]	Set. COD
90064	Settled BOD_5, [mg/l]	Set. BOD_5
90065	Percent suspended solids on 75μ filter, [%]	
90066	Percent suspended solids on 24μ filter, [%]	
90067	Percent suspended solids on 5μ filter, [%]	
90068	Percent suspended solids on 0.45μ filter, [%]	
90069	Bioassay, percent survival in undiluted waste, 96 hrs, [%]	
90070	Toxicity, percent survival in undiluted waste, 96 hrs,[%]	
90100	Dry days preceding storm, [days]	

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[a] Code also used for total storm depths as defined by data source, (i.e., the storm duration may be unequal to one day).

[b] Code also used for conduit flows (most urban data).

[c] Code also used for settleable solids at 60 min.

Table VI-3 (concluded) Footnotes

[d] Note: On data tape, coliforms, etc. are given as 100-$\log_{10}$ (MPN/100ml).

[e] Storm duration given in absence of detailed rainfall hyetograph.

[f] Parameters 9855 - 9870 used only for San Francisco (34,35).

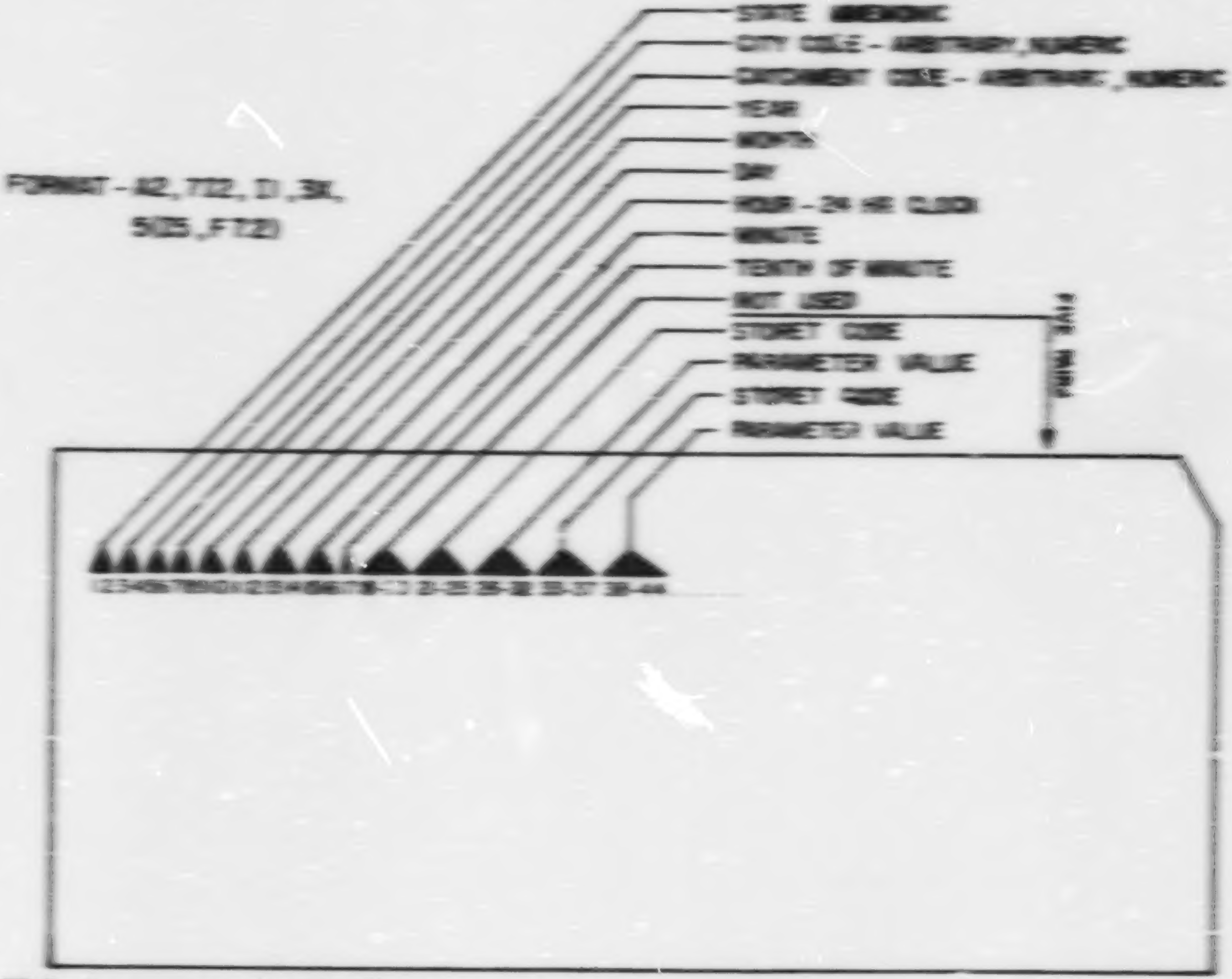

FORMAT-A2,7I2,I1,3X,
5(I5,F7.2)
STATE MNEMONIC
CITY CODE-ARBITRARY,NUMERIC
CATCHMENT CODE-ARBITRARY,NUMERIC
YEAR
MONTH
DAY
HOUR-24 HR CLOCK
MINUTE
TENTH OF MINUTE
NOT USED
STORET CODE
PARAMETER VALUE
STORET CODE
PARAMETER VALUE
FIVE PAIRS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18-20 21-25 26-32 33-37 38-44

Figure VI-1 Arrangement of identification codes and data on computer card.

Figure VI-2 Example of data grouping for Seattle, Washington

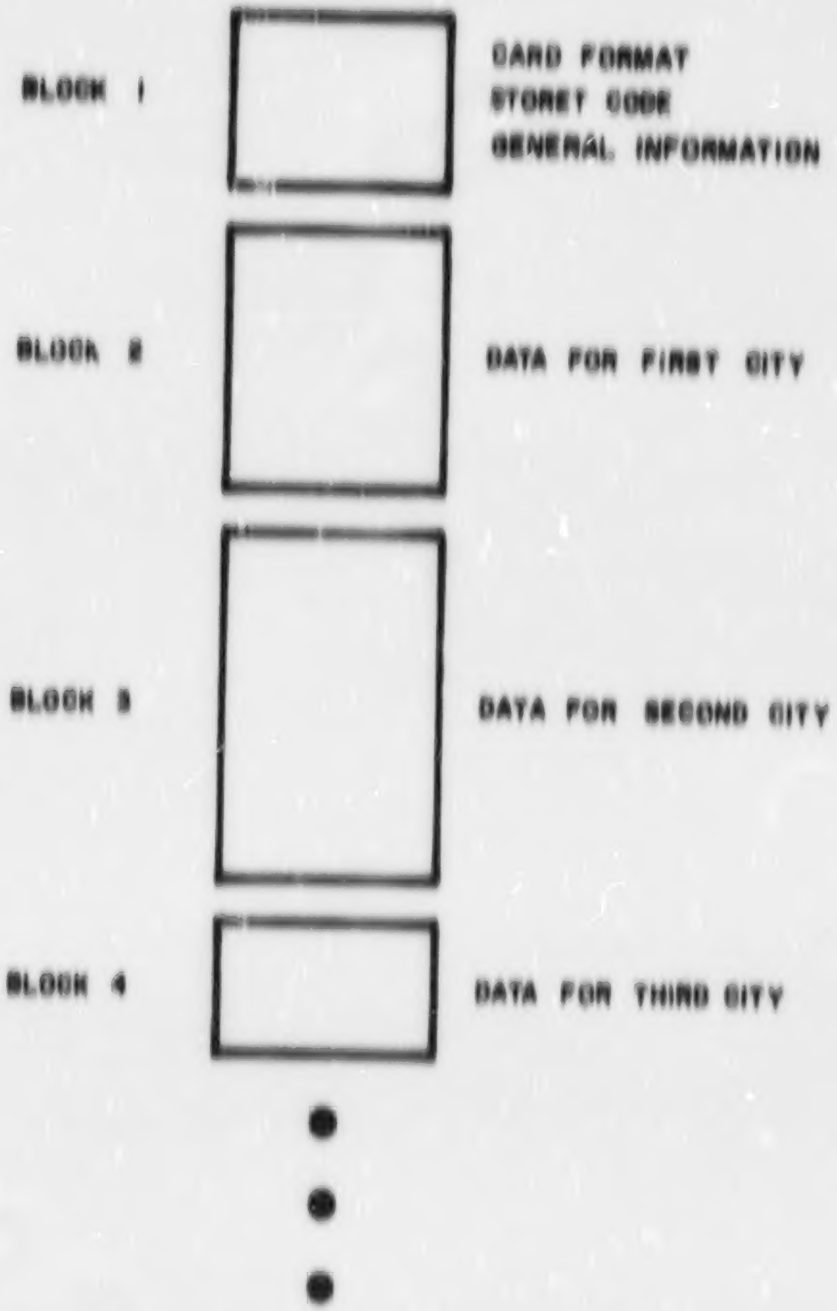

BLOCK 1
CARD FORMAT
STORET CODE
GENERAL INFORMATION
BLOCK 2
DATA FOR FIRST CITY
BLOCK 3
DATA FOR SECOND CITY
BLOCK 4
DATA FOR THIRD CITY

Figure VI-3 Arrangement of data on magnetic tape. Data within each block resemble those shown in Figure VI-2.

Data may be utilized for comparison with modeling results simply by obtaining a listing ("dump") of the tape contents. Alternatively, only selected parameters may be retrieved from the tape if desired. The tape itself may be utilized for statistical analyses and characterization purposes, although in practice such manipulations will be better served after having placed the data onto a disk, drum or other rapid-access storage device.

In the future, the data will also be entered directly into the STORET system. This should facilitate nationwide access as well as permit use of STORET software for statistical and other analyses. Future addenda will provide necessary information to permit access to the data when they are placed on STORET.

SECTION VII

DESCRIPTION OF RAINFALL-RUNOFF-QUALITY DATA BASE SOURCES

INTRODUCTION

The following subsections describe locations for which rainfall, runoff and quality data have been obtained that are suitable for the data base. Additional locations with rainfall-runoff data only are described in Section VIII.

Sources included in this section were chosen primarily on the basis of known high quality of the data, availability and documentation. The first consideration was checked primarily by familiarization with the sampling program, careful review of the documentation and personal conversations with the responsible personnel. The latter two considerations were the keys to actually obtaining, reducing (in some cases), key punching, etc. the data for inclusion on the magnetic tape. Since UF is distant from most of the sources, the only way in which these operations could be accomplished was to have good documentation provided in some form. In all cases, data values were inspected visually for reasonableness. Where data were key punched at UF, spot checks were made against the source listing.

Each location has tables describing the catchments, quantity sampling program, quality sampling program, quality data sampled, and, in a few cases, additional information. Similar tables for different locations differ in content according to the available information at each location. In all cases, additional useful information may be obtained from the cited references.

The amount of modeling data contained in-house by UF varies considerably from location to location and is increasing with time. Requests should be made directly to UF to the persons indicated below for information on data for individual catchments.

Wayne C. Huber, or
James P. Heaney or
W. Alan Peltz

Department of Environmental Engineering Sciences
University of Florida
Gainesville, Florida 32611

(904)392-0846

BROWARD COUNTY, FLORIDA

The Water Resources Division of The Miami office of the U.S. Geological Survey (USGS) initiated monitoring of stormwater runoff at three sites with different land uses in northeast Broward County (Fort Lauderdale area) in 1974 in cooperation with the county and with the Florida Department of Transportation (104, 105). In addition to the extensive amount of quality sampling being done, an added advantage of this program is that all quality data are being placed directly into the STORET system, and are thus accessible by many users. Flow and rainfall data are not in the STORET files and were obtained by UF directly from USGS. Early data have been used for model comparisons (172).

All quality data were retrieved from STORET and placed in the same format as other data on the data tape. Further data will be added to the data tape as they become available. Overall, these data are among the very best included in the data base, in terms of volume, care in sampling, sophistication of instrumentation and accessibility.

State and City Code: FL 01

Table VIII-1. Catchments - Broward County

No.	Name	Area, ac (ha)	Population	Drainage System	STORET Location ID	Land Use
1	Residential (near NE 31 St. and US1)[b]	47.5 (19.2)	[illegible][a]	Storm[f]	[illegible]	House roofs, 19%;drive ways,5%; roads,11%; lawns,62%.
2	Transportation (Sample Rd. near I-75)[b]	39.0 (15.8)		Storm	[illegible]	Arterial Highway(does not include Interstate hwy. drainage).[d]
3	Commercial (Coral Ridge Shopping Plaza, near NE 35 St. and US1)[c]	28.4 (11.5)		Storm	[illegible]	Shopping Center[e]

---

[a] Estimated using 151 single family houses.

[b] North of Pompano Beach, Florida

[c] In north Ft. Lauderdale, Florida

[d] Roadway and connected parking lots 13.7 ac (5.6ha), permeable lawns 24.3 ac (9.8ha) and rooftops 1.0 ac (0.4ha).

[e] Pavement 19.7 ac (8.0ha), vegetation 0.4 ac (0.16ha) and rooftops draining to sewer 8.3 ac (3.4ha).

[f] Open-channel, swale drainage

Table VII-2. Quantity Data - Broward County

		Flow		Rain					
			Sampling	Gages Used			Sampling		
No.	Catchment	Type of Flow meas.	Interval, min	No. in Catchment	No. near Catchment	Type	Interval, min	No. of Storms	Period
1	Residential	f_1	5^a	3	0	r_1	5^a	35^b	4/74-9/75
2	Transportation	f_1	5	2	0	r_1	5	16^b	4/75-9/75
3	Commercial	f_1	5	1	0	r_1	5	4^b	

---

f_1 - Fiberglass U-shaped, venturi-type constriction mounted in 36 in. (914 mm), 54 in. (1372 mm), and 36 in. (914 mm) pipes at sites 1, 2 and 3, respectively. Calibrated in laboratory. Stage measured by nitrogen gas bubbler tube.

r_1 - Weather Measure Model P-501 tipping bucket gage; bucket capacity = 0.01 in. (0.25 mm). Average of gages is used at sites 1 and 2.

[a] Flow and rain monitored continuously, but data are reduced to 5 min. increments.

[b] Rain/Flow data pending reduction by USGS

Time synchronization, flow-rain: Excellent since data are telemetered to same multiple pen strip chart recorder.

Table VIII-1. Quality Sampling - Broward County

No.	Catchment	Sampling Method	Sampling Interval, min.	Sampling Location	No. of Storms	Period
1	Residential	a_1	1-15	Outfall pipe	35^a	4/74-9/75
2	Transportation	a_1	1-15	Outfall pipe	14^a	4/75-1/76
3	Commercial	a_1	1-15	Outfall pipe	4^a	

---

[a] Number of storms currently (8/76) in STORET file. More to be added.

a_1 - ISCO continuous flow automatic sampler 28 (0.53 gal.) bottles

Time synchronization, flow-quality: Good since time of sample noted on same strip chart recorder as used for rain-flow.

Table VII-4. Quality Parameters - Broward County

Not all parameters are available for all storms at all catchments.

Parameter	STORET Code	Units
Temperature	10[a]	°C
Stage	65[a]	ft
Turbidity	70	JTU
Color	80	PCU
Conductivity	95	umho
Dis. Oxygen	300[a]	mg/l
DO, % saturation	301	%
BOD_5	310	mg/l
COD	340	mg/l
pH	400	
CO_2	405	mg/l as CO_2
Tot. Alkalinity	410	mg/l as $CaCO_3$
HCO_3 ion	440	mg/l as HCO_3
CO_3 ion	445	mg/l as CO_3
Tot. Solids	500	mg/l
Dis. Solids	515	mg/l
Tot. N	600	mg/l-N
Tot. Organic N	605	mg/l-N
NH_3-N	610	mg/l-N
NO_2-N	615	mg/l-N
NO_3-N	620	mg/l-N
TKN	625	mg/l-N
NO_2 + NO_3-N	630	mg/l-N
Tot. P	665	mg/l-P
Tot. Organic C	680	mg/l-C
Tot. Inorganic C	685	mg/l-C
Tot. C	690	mg/l-C
Cl	940	mg/l
Dis. Silica	955	mg/l as SiO_2
Cd	1027	ug/l
Cr	1034	ug/l

---

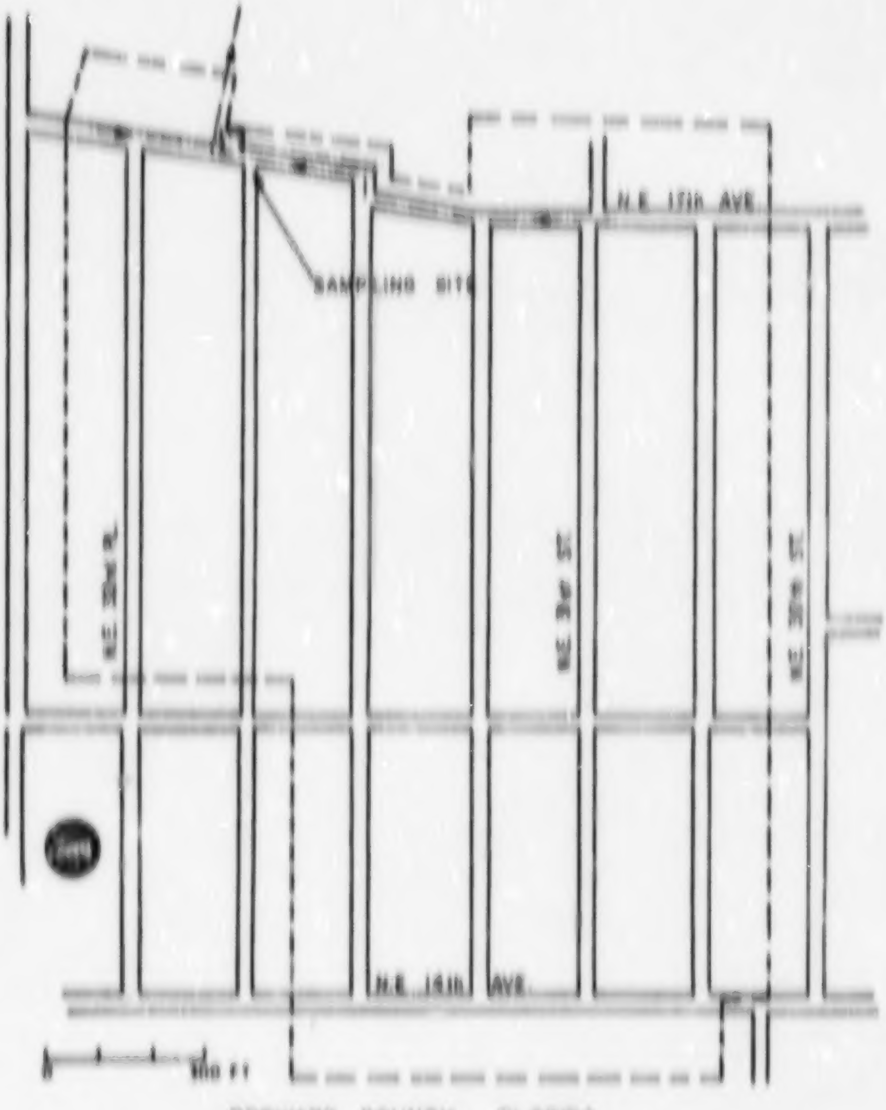
[a] No values yet stored on STORET file

Table VII-4. (concluded)

Parameter	STORET Code	Units
Cu	1042	ug/l
Fe	1045	ug/l
Pb	1051	ug/l
Zn	1092	ug/l
Tot. Colif.	31501	MPN/100 ml[a]
Fec. Colif.	31616	MPN/100 ml[a]
Fec. Strep.	31679	MPN/100 ml[a]
Susp. Solids by evap @ 180°C	70299	mg/l
OPO_4-P	70507	mg/l-P
Tot. N as NO_3	71887	mg/l as NO_3

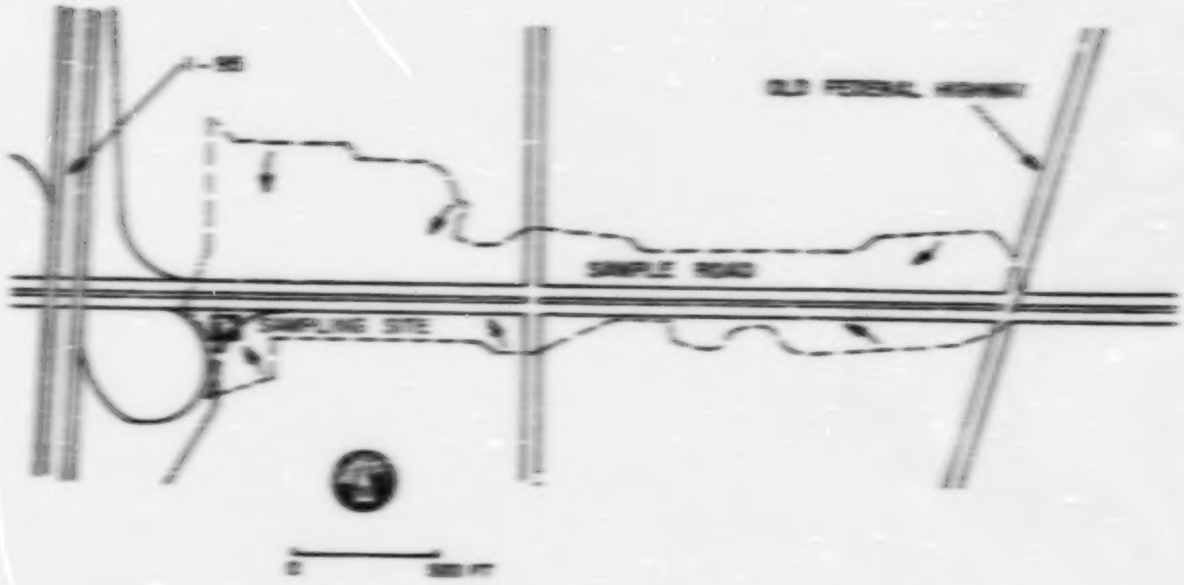
---

[a] On data tape, coliforms reported as 100 x $\log_{10}$ (MPN/100 ml).


N.E. 17th AVE.
SAMPLING SITE
N.E. 32nd PL
N.E. 33rd ST
N.E. 35th ST
N.E. 14th AVE.
0
500 FT

BROWARD COUNTY , FLORIDA
RESIDENTIAL CATCHMENT (FL 1 1)

Figure VII-1 Broward County, Florida, Residential Catchment, 47.5 ac (19.2 ha)


I-95
OLD FEDERAL HIGHWAY
SAMPLE ROAD
SAMPLING SITE
0
500 FT

BROWARD COUNTY, FLORIDA
TRANSPORTATION CATCHMENT (FL 1 2)

Figure VII-2 Broward County, Florida, Transportation Catchment, 39.0 ac (15.8 ha). Scale is approximate.

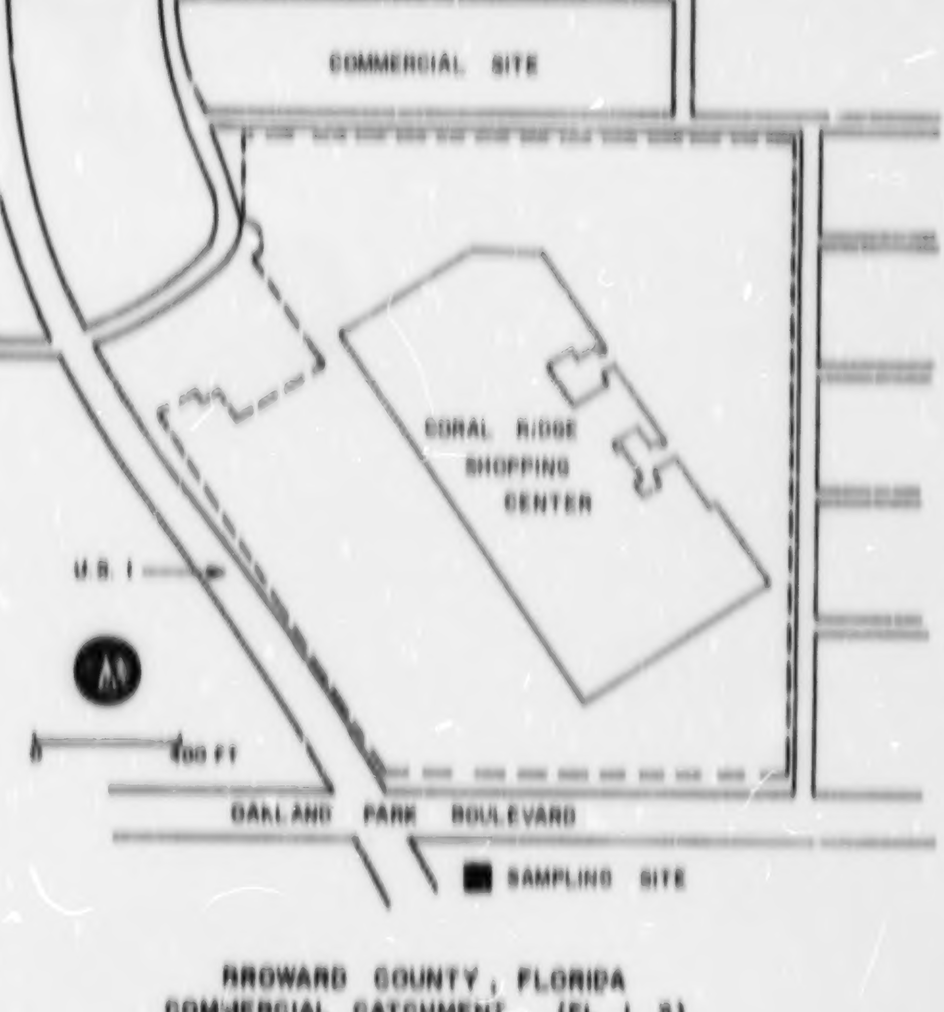

COMMERCIAL SITE
CORAL RIDGE SHOPPING CENTER
U.S. 1
0
400 FT
OAKLAND PARK BOULEVARD
SAMPLING SITE
BROWARD COUNTY, FLORIDA
COMMERCIAL CATCHMENT (FL 1 5)

Figure VII-3 Broward County, Florida, Commercial Catchment, 28.4 ac (11.5 ha) Scale is approximate.

DURHAM, NORTH CAROLINA

The 1069 ac (433 ha) Third Fork Basin in Durham has been monitored for rainfall-runoff data by the USGS as reported by Tucker (42). The RRL and ILLUDAS models were tested on these data (49,50), and keypunched rainfall-runoff data for 1969 were received through the courtesy of the Illinois State Water Survey. These data have also been used for hydrograph analyses (176).

Quality sampling was performed in 1969 by Bryan (133,134) and in 1971-1973 by Colston (135). Bryan's data were in the form of composite samples and are not included in the data base. Of the several storms sampled by Colston, rainfall data are reported for four and included herein. Colston's report (135) also contains useful catchment information and examples of SWMM modeling. All data for the catchment are considered to be good due to the careful processing of rainfall-runoff data by the USGS and analysis of the quality data by Colston. However, measurements of BOD_5 were not reproducible, and it was Colston's recommendation that they not be used as an indicator of water quality. In addition, due to the fact that the quality samples were taken from the bottom, suspended solids measurements may not be representative of the entire vertical solids profile.

State and City Code: NC 02

Table VII-5. Catchments - Durham

No.	Name	Area ac (ha)	Sewerage	Population	Imperviousness %	Ave. Land Slope, %	Land Use Percentages
1	Third Fork	1069 (433)	Storm (open channels)	6400	25[a]	7.6	Res. 24, com. and ind. 19, public and institutional 12, open 10.

[a] Paved 16%, rooftops 9, unpaved streets 3, vegetation 66.

Table VII-6. Quantity Data - Durham

		Flow		Rain					
				Gages Used					
No.	Catchment	Type of Flow meas.	Sampling Interval, min	No. in Catchment	No. near Catchment	Type	Sampling Interval, min	No. of Storms	Period
1	Third Fork	f_1	5	1	-	r_1	5	15	6/69-2/70
								4	6/72-10/72

f_1 - Continuous stage measurement at V-notch weir, connected to digital tape punch recorder. USGS station no. 02097243.

r_1 - Float-type rain gage with punched record.

Time synchronization: Good since rain gage and stage gage use same clock.

Table VIII-7. Quality Sampling - Durham

No.	Catchment	Sampling Method	Sampling Interval min.	Sampling Location	No. Storms	Period
1	Third Fork	a_1	12 - 30	Basin outlet at USGS weir	4	6/72-10/72

---

a_1 - Pumped to Serco Model NW-3 automatic sampler, modified slightly as described by Colston (135). Sample volume was 0.35 l. Inlet pump was anchored near stream bed immediately below weir.

Time synchronization , flow-quality: Good since USGS and quality sampling clocks were housed in same facility and could be cross checked.

Table VII-8. Quality Parameters - Durham

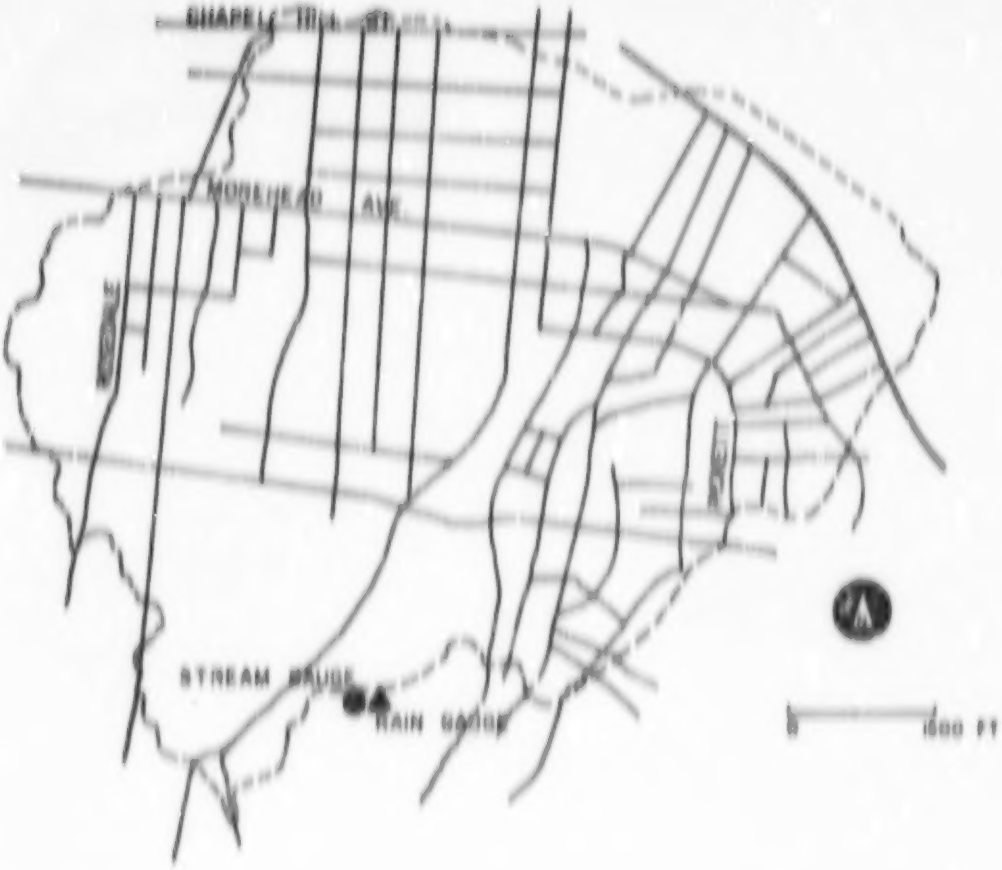
Not all parameters are given for all storms.

Parameter	STORET Code	Units
BOD_5	310	mg/l
COD	340	mg/l
Dis. COD	341	mg/l
pH	400	mg/l
Tot. Alkalinity	410	mg/l as $CaCO_3$
Tot. Solids	500	mg/l
Tot. Vol. Solids	505	mg/l
Suspended Solids	530	mg/l
Vol. Susp. Solids	535	mg/l
TKN	625	mg/l - N
Tot. P	665	mg/l - P
Tot. Organic C	680	mg/l - C
Ca	916	mg/l
Mg	927	mg/l
Cr	1034	ug/l
Cu	1041	ug/l
Fe	1045	ug/l
Pb	1051	ug/l
Mn	1055	ug/l
Al	1107	ug/l
Fec. Coliform	31616	MPN/100ml[a]

---

[a] On data tape, coliforms reported as 100 x $\log_{10}$ (MPN/100ml).

Cobalt, nickeland strontium were also measured but all values were less than the detection level of 100 ug/l.


CHAPEL HILL ST.
MOREHEAD AVE.
STREAM GAUGE
RAIN GAUGE
0
1000 FT

DURHAM, N. C.
THIRD FORK CATCHMENT
(NC 2 1)

Figure VII-4 Durham, N.C., Third Fork Catchment, 1069 ac (433 ha).

LANCASTER, PENNSYLVANIA

Data were taken from the 134 acre (54.2 ha) Stevens Avenue catchment as part of the Swirl Regulator Demonstration Project (EPA Grant S802219, formerly 11023 GSC) being undertaken at that location. In preparation for construction of a swirl regulator/concentrator at the Stevens Avenue outfall to Connestoga Creek, monitoring was performed in 1973-74 by the City of Lancaster and Meridian Engineering of Philadelphia. As a participant in the project, the University of Florida received data on a routine basis and has used the combined-sewered Stevens Avenue catchment as a study area in a previous report (106).

All data were collected and analysed by the city; however, depth, pH, DO, conductivity and temperature were reduced directly from the original strip charts by UF. Rainfall data were similarly reduced by UF from xerox copies of the charts. Quality data are felt to be good at this location. Flow data are not as good since they were obtained using Manning's equation to convert measured depths. However, supercritical flow at the measuring point eliminates any backwater effects.

State and City Code: PA 01

Table VII-9. Catchments - Lancaster

Name	Area ac (ha)	Population	Drainage System	DWF cfs (l/sec)	Ave Runoff Coef	Land Use
1. Stevens Avenue	134 (54.2)	3600	Combined	0.6-0.9 (17-25)	0.39	Single-family res., 90% Multi-family res., 10%

Table VII-10. Quantity Data - Lancaster

	Flow		Rain					
			Gages Used					
Catchment	Type of Flow Meas	Sampling Interval min	No. in Catchment	No. near Catchment	Type	Sampling Interval min	No. Storms	Period
Stevens Avenue	f_1	1.5	1	0	r_1	5	6	9/73 - 1/74

---

f_1 – Depth measurement in 60 in. (152 cm) RCP sewer by Controlotron Corp 290-1 sonic water level sensor. Continuous strip chart records of depth were converted to flow by UF using Manning equation, n = 0.013, slope = 0.035 (note that flow is supercritical). Measured depths are also given in data tabulation.

r_1 = Weighing bucket raingage at [illegible]. 24-hour strip charts.

Time synchronization, rain-flow: possible errors due to separate clocks.

Table VII-22. Quality Sampling - Lancaster

Catchment	Sampling Method	Sampling Interval min	Sampling Location	No. Storms	Period
Stevens Avenue	a_1	1.5-60	Diversion Structure	6	9/73 - 1/74

---

a_1 - pH, conductivity, DO, temperature by Ohmart Corp Model 1-1000-2 probe sensor. Recorded on Westronic multiple-pen strip chart along with depth measurement. Other parameters by [illegible] Model 4E-4 automatic sampler (connected to Ohmart sampler pumps) into 2 liter (0.53 gal) bottles.

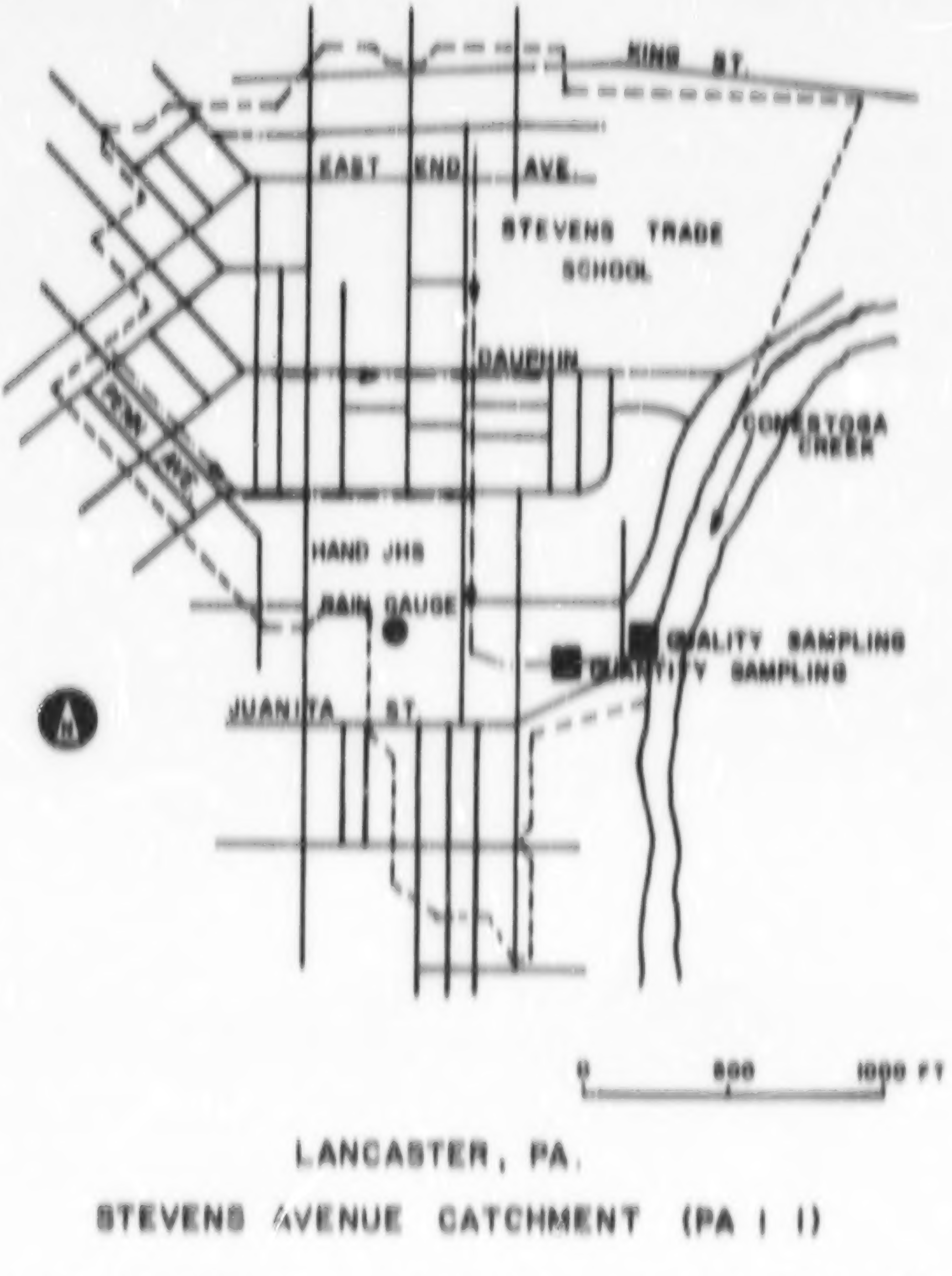
Time synchronization, flow-quality: good because data recorded on same strip chart.

Table VII-12. Quality Parameters - Lancaster

Not all parameters are given for all storms.

Parameter	STORET Code	Units
Conductivity (probe)	94	u mhos
Dis. Oxygen (probe)	299	mg/l
pH (probe)	400	
Temperature (probe)	11	°F
Sus. Solids (SS)	530	mg/l
Fixed SS	540	mg/l
Vol. SS	535	mg/l
Dis. Solids	515	mg/l
Tot. Solids	500	mg/l
BOD_5	310	mg/l
BOD_{20}	324	mg/l
COD	340	mg/l
TOC	680	mg/l
Tot. Cd	1027	ug/l
Tot. Cr	1034	ug/l
Tot. Cu	1042	ug/l
Tot. Pb	1051	ug/l
Tot. Zn	1092	ug/l
Chloride	940	mg/l
Tot. Org. N	605	mg/l-N
NH_3-N	610	mg/l-N
NO_3-N	620	mg/l-N
NO_2-N	615	mg/l-N
OPO_4-P	70507	mg/l-P
Tot. P	665	mg/l-P
Hydrolis. P	669	mg/l-P
Depth	50055	in.
Flow	61	cfs
Rain	90050	in./hr

Grease/oil, total coliforms and fecal coliforms were listed as part of the sampling program, but no data were given for the storms used.


KING ST.
EAST END AVE.
STEVENS TRADE SCHOOL
DAUPHIN
PENN AVE.
CONESTOGA CREEK
HAND JHS
RAIN GAUGE
QUALITY SAMPLING
QUANTITY SAMPLING
JUANITA ST.
N
0
500
1000 FT

LANCASTER, PA.

STEVENS AVENUE CATCHMENT (PA I I)

Figure VII-5 Lancaster, Pennsylvania, Stevens Ave. Catchment, 134 ac (54.2 ha).

LINCOLN, NEBRASKA

Quantity and quality data were gathered for the three residential catchments as part of OWRT-sponsored research conducted by the University of Nebraska. The period of study was April 1972 to May 1974.

Data were taken from a thesis (107) and completion report (56) and reduced prior to receipt by UF. Additional information on rainfall was received from R. Sallach (personal communications, 1975, 1976). These data are considered to be of good quality, on the basis of discussions with University of Nebraska personnel.

State and City Code: NB 01

Table VII-13. Catchments - Lincoln

No.	Name	Area ac (ha)	Sewerage	Population	Imperviousness (%)	Length of Streets mi (km)	Land Use
1	39th & Holdrege	79 (32)	Storm[c]	822[a]	30		Residential
2	63rd & Holdrege	85 (34.4)	Storm[c]	381[b]	36-40	4.3 (6.9)	Residential
3	70th & A St.	257 (104)	Storm[c]		25		Developing residential, open, farm

---

[a] 1952 population. Estimated 1975 population density = 11.3 persons/ac (27.9 persons/ha).

[b] 1952 population. Estimated 1975 population density = 7.9 persons/ac (19.5 persons/ha).

[c] Open channels.

Table VII-24. Quantity Data - Lincoln

Catchment	Flow: Type of Flow Meas	Flow: Sampling Interval min	Rain: Gages Used: No. in Catchment	Rain: Gages Used: No. near Catchment	Rain: Type	Rain: Sampling Interval min	No. Storms	Period
39th & Holdrege	f_1	10-15	1	0	r_1	15-90	20	4/72 - 5/74
[illegible] & Holdrege	f_2	10-15	0	1	r_1	15-90	15	4/72 - 5/74
70th & A St.	f_3	10-15	1	0	r_1	15-90	14	4/72 - 7/73

---

f_1 - Visual head measurement on sharp-crested rectangular weir in open channel 20 ft (6.1 m) downstream of 48 in. (1220mm) concrete sewer.

f_2 - Visual readings of depth markings on wall of 48 in. (1220mm) sewer. Converted to flow using Manning's equation.

f_3 - Visual readings of markings on wall of 5 x 10 ft(1.5x3.0m) concrete box culvert in open drainage ditch. Velocity measurements used to develop stage-discharge relationship.

r_1 - Standard USGS recording rain gages with seven day clock.

Time synchronization: Rain-flow dependent upon different clocks. Possibility of occasional time shift between flow and rainfall measurements.

Comment: Time sequence of rainfall is poorly defined for many storms due to reduction of data over long time periods (e.g., rainfall totals reported at 90 min intervals for some storms).

Table VII-15. Quality Sampling - Lincoln

No.	Catchment	Sampling Method	Sampling Interval min	Sampling Location	No. Storms	Period
1	39th & Holdrege	a_1	10-15	At weir downstream of 48 in. (1220 mm) sewer	20	4/72 - 5/74
2	63rd & Holdrege	a_1	10-15	At outlet of 48 in. (1220mm) sewer	15	4/72 - 5/74
3	70th & A St.	a_1	10-15	In box culvert in open drainage ditch	14	4/72 - 5/74

---

a_1 - Manual grab samples.

Time synchronization, flow-quality: good since both kinds of data recorded simultaneously at same point.

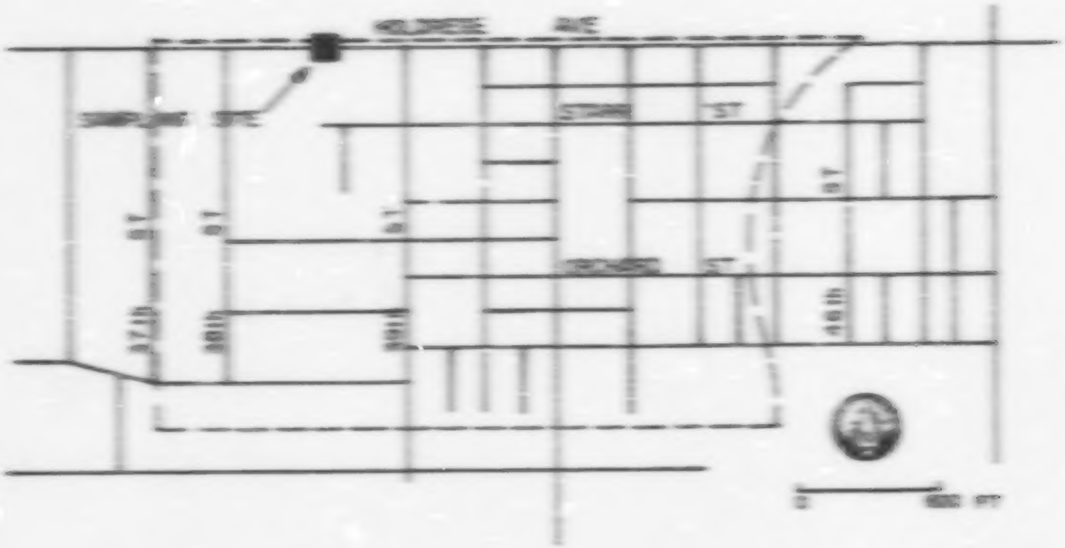
Table VII-16. Quality Parameters - Lincoln

Not all parameters were recorded for all storms at all locations.

Parameter	Catchment No.	STORET Code	Units
BOD_5	All	310	mg/l
COD	All	340	mg/l
VSS	All	535	mg/l
TS	All	500	mg/l
TVS	All	505	mg/l
SS	All	530	mg/l
NO_3-N	All	620	mg/l
Org-N	All	605	mg/l-N
OPO_4-P (soluble)	All	671	mg/l-N
Spec. Conductivity	All	95	mg/l-P
Turbidity	All	70	μ mho
Tot. Colif.	All	31503	JTU
Salinity	All	480	MPN/100 ml[a]
			ppt

---

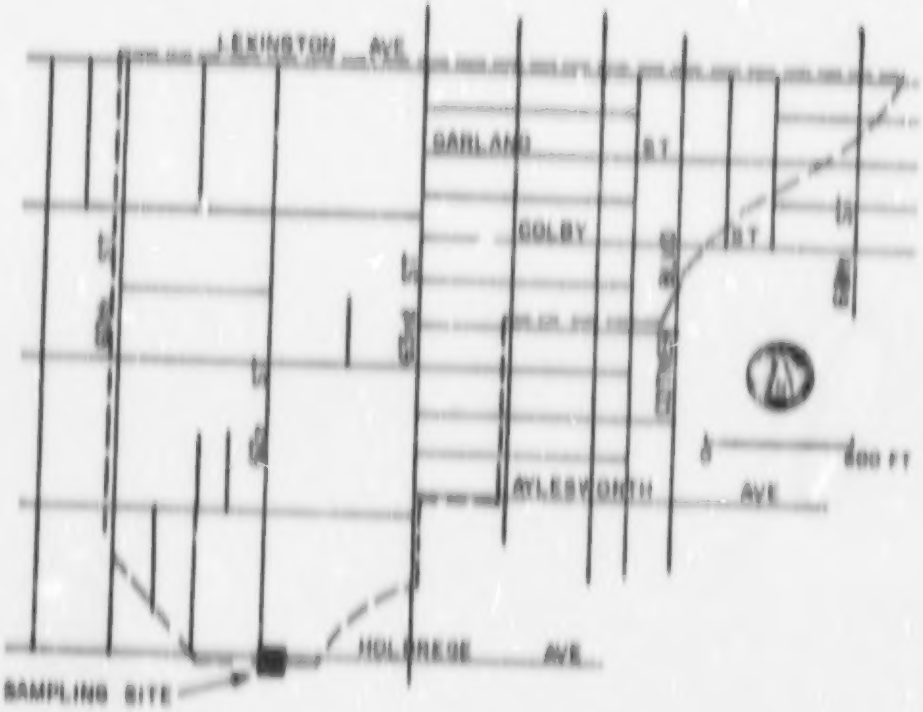
[a] Note: On data tape, coliforms are given as 100 x $\log_{10}$ (MPN/100 ml)


HOLDREGE AVE
SAMPLING SITE
STARR ST
ORCHARD ST
37th ST
38th ST
39th ST
46th ST
0
600 FT

LINCOLN , NEBRASKA

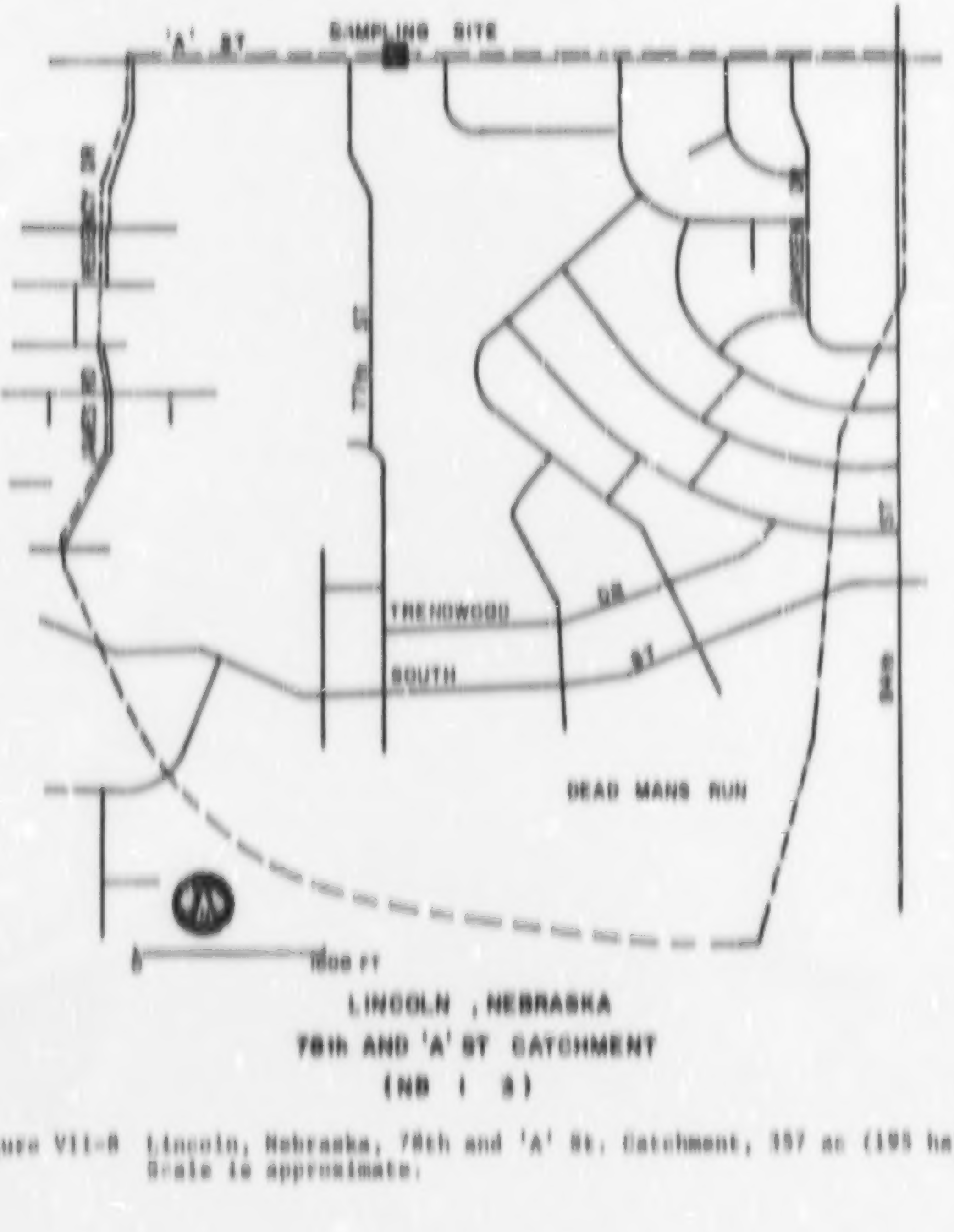
39th AND HOLDREGE CATCHMENT (NB : 1)

Figure VIII-6 Lincoln, Nebraska, 39th and Holdrege Catchment, 79 ac (32 ha). Scale is approximate.


LEXINGTON AVE
GARLAND ST
COLBY ST
AYLESWORTH AVE
HOLDREGE AVE
SAMPLING SITE
0
600 FT

LINCOLN, NEBRASKA
63rd AND HOLDREGE CATCHMENT (NB I 2)

Figure VII-7 Lincoln, Nebraska, 63rd and Holdrege Catchment, 85 ac (39.4 ha). Scale is approximate.


'A' ST
SAMPLING SITE
77th ST
TRENDWOOD DR
SOUTH ST
ST
DEAD MANS RUN
0
1000 FT

LINCOLN , NEBRASKA
78th AND 'A' ST CATCHMENT
(NB 1 3)

Figure VII-8 Lincoln, Nebraska, 78th and 'A' St. Catchment, 357 ac (195 ha). Scale is approximate.

RACINE, WISCONSIN

Data were taken from a draft report (108) of a detailed study performed by Envirex, Inc. involving an extended monitoring program. The flow data are somewhat difficult to interpret since runoff from the catchment is split between two outlets, Site I and Site II, and difficulties were experienced in flow measurements at Site II. Thus, proper interpretation of the Site I runoff data must rely upon accurate analysis of upstream diversion structures. It is understood that this information will be contained in the final version of the report. All data are taken from the draft report and were reduced prior to to receipt by UF. Additional quality parameters beyond the three included herein were also monitored and will be included in the data base at a future date.

State and City Code: WI 01

Table VIII-17. Catchments - Racine

No.	Name	Area ac (ha)	Population	Sewerage	Land Use Percentages
1	Site I	829.3 (335.6)	9847[a]	Combined	Single Fam. Res. 63, Multi-Fam. Res. 10, Com. 12, Ind. 9, Park 6

---

[a] Population of residential land use only.

Table VII-18. Quantity Data - Racine

	Flow		Rain					
			Gages Used					
Catchment	Type of Flow Meas.	Sampling Interval min	No. in Catchment	No. near Catchment	Type	Sampling Interval min	No. Storms	Period
Site I	E_1	10	2	1	R_1	5	9	7/73 - 8/74

E_1 - At Site I, total flow is sum of pumped flow to treatment plant, measured by Parshall flume, plus weir overflow, determined by bubbler tube measurement of stage at diversion structure. Stage measurements in Parshall flume were variable, hence results are given in terms of a range (minimum and maximum) at each time step.

R_1 - Results, weighing bucket recording gages. Value reported is from the one out of three sites selected for modeling of the particular storm.

Time synchronization: flow-rain, dependent upon separate clocks on rain and stage gages. Possibility of time shifts between two sets of data. No problems reported.

Comment: In the reference report flow was recorded at two sites in the catchment. Data in this report is only for Site I since there were many problems with the accuracy of Site II. When comparing with modeling results, characteristics of flow dividers upstream from Sites I and II must be considered since total runoff from catchment is split between Sites I and II.

Table VIII-29. Quality Sampling - Racine

No.	Catchment	Sampling Method	Sampling Interval min	Sampling Location	No. Storms	Period
1	Site 1	s_1	10-30	Wet well at lift station [illegible] treatment plant	6	11/73 - 8/74

---

s_1 - grab samples.

Time synchronization: flow-quality, good since data gathered simultaneously at same location.

Table VIII-30. Quality Parameters - Racine

Not all parameters are available at all times for all storms.

Parameter	STORET Code	Units
BOD_5	310	mg/l
SS	530	mg/l
Tot. Colif.	31501	MPN/100 ml[a]

---

[a] On data tape, coliforms are given as 100 x $\log_{10}$ (MPN/100 ml).

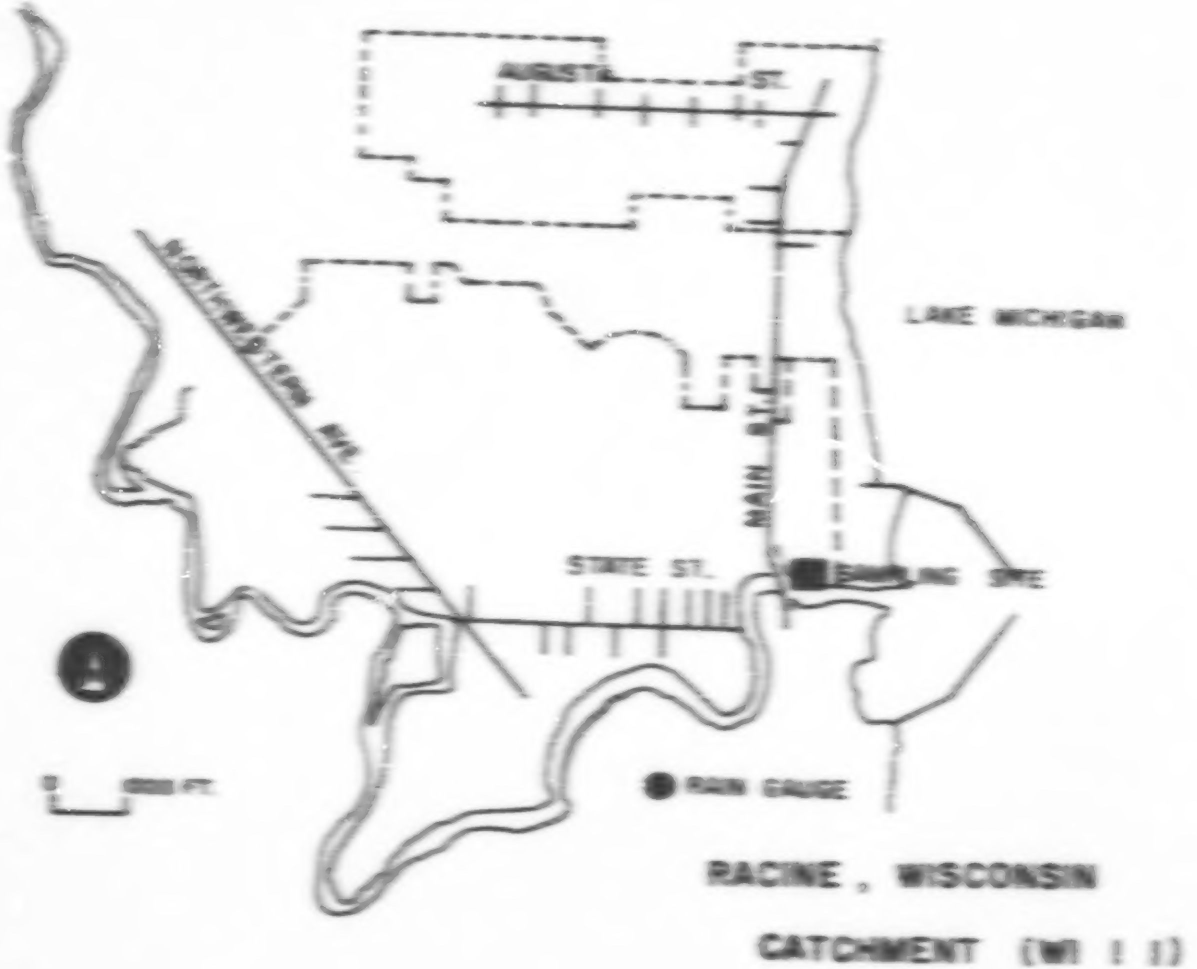

AUGUSTA ST.
NORTHWESTERN AVE.
LAKE MICHIGAN
MAIN ST.
STATE ST.
SAMPLING SITE
RAIN GAUGE
0
FT.
RACINE, WISCONSIN
CATCHMENT (WI I 1)

Figure VII-9 Racine, Wisconsin, Site I Catchment, 829 ac (335 ha).

SAN FRANCISCO, CALIFORNIA

Flow and quality data included in the report were collected by Engineering Science, Inc., for the City of San Francisco during 1966-70(34,35,175). Six catchments were monitored in the study, five mainly residential and one mainly industrial. Although the volume of data (i.e., number of storms sampled) is small, the data themselves are considered good and represent one of the earlier efforts in monitoring overflow points for later model calibration.

All data were acquired and reduced by the staff of Engineering Science and are taken directly from their reports. They have been used previously for model verification(102,143-145,178). All rainfall values included on the data tape were read from graphs since no tabulation was provided.

The City of San Francisco instituted in 1972 an extensive network of tipping-bucket rain gages and bubbler stage measurements throughout the City. These data are stored on several hundred magnetic tapes by the City but have not been reduced to a convenient form for modeling to date.

State and City Code: CA 01

Table VII-21. Catchments - San Francisco

No.	Name	Area ac (ha)	Sewerage	Population	No. Catchbasins	Streets, mi (km)	Land Use Percentages
1	Baker St.	168 (68)	Combined	13,200	140	8.75 (14.0)	Res 80, Com 8, Vac 12
2	Mariposa St.	223 (90)	Combined	4,500	145	8.45 (13.5)	Res 29, Ind 36, Vac 14, Other 21
3	Brotherhood Way	180 (73)	Combined	5,100	114	11.6 (18.6)	Res 77, Com 6 Govt 11, Other 6
4	Vicente St., North	16 (6.5)	Storm	400^a	12^a	1.32 (2.1)	Res 100
5	Vicente St., South	21 (8.5)	Storm	500^a	15^a	1.64 (2.6)	Res 80, Com 15, Other 5
6	Selby St.	3400 (1380)	Combined	81,000	2300	136 (217)	Res 77, Com 2, Ind 6, Vac 15
7	Laguna St.	375 (152)	Combined	25,300	250	17.2 (27.5)	Res 62, Com 16, Ind 6, Other 16

---

[a] Estimated

Table VIII-22. Quantity Data - San Francisco

No.	Catchment	Flow: Type of Flow Meas	Flow: Sampling Interval min	Rain: Gages Used: No. in Catchment	Rain: Gages Used: No. near Catchment	Rain: Type	Rain: Sampling Interval min	No. Storms	Period
1	Baker St.	f_1	5-10	1	Fed Bldg	r_1	10	3	4/69 - 12/69
2	Mariposa St.	f_1	5-10	1	Fed Bldg	r_1	10	5	2/69 - 4/69
3	Brotherhood Way	f_1	5-10	1	Fed Bldg	r_1	10	3	1/70
4	Vicente St., N	f_1	5-10	1		r_1	10	1	2/70
5	Vicente St., S	f_1	5-10	1		r_1	10	1	2/70
6	Selby St.	f_2	5-10	1	Fed Bldg	r_1	10	8	11/66 - 3/67
7	Laguna St.	f_3	5-10	1		r_2	5-10	2	3/67

f_1 - Dye dilution, using pumped dye inflow 500-700 ft (150-210 m) upstream from diversion structure. Reported flows corrected for assumed flow into interceptor.

f_2 - Depth measurement at outfall structure. Stage-discharge calibration over weir. Interceptor blocked during storms, so reported flows are overflows over weir. A volume of approximately 5.3×10^5 ft^3 (1.5×10^4 m^3) in overflow structure and trunk sewer must be filled at beginning of storm prior to overflow.

f_3 - Depth measurement in sewer outfall, converted to flow by Manning equation. Flows apparently uncorrected for "small" amount diverted to interceptor during storms.

r_1 - Unspecified recording raingage. Rainfall measured at Federal Building by US Weather Service occasionally used, but not indicated as to which storms.

r_2 - Homemade gage using graduated cylinder, read at fixed time intervals.

Time synchronization: dependent on different clocks in different gages. Possibility of occasional time shift between flow and rainfall measurements.

Table VIII-21. Quality Sampling - San Francisco

No.	Catchment	Sampling Method	Sampling Interval min	Sampling Location	No. Storms	Period
1	Baker St.	a_1	≥ 10	Above diversion structure	3	4/69 - 11/69
2	Mariposa St.	a_1	≥ 10	Diversion structure	3	2/69 - 4/69
3	Brotherhood Way	a_1	≥ 10	Above diversion structure	3	1/70
4	Vicente St., North	a_1	≥ 10	Diversion structure	1	2/70
5	Vicente St., South	a_1	≥ 10	Diversion structure	1	2/70
6	Selby St.	a_2	≥ 10	Diversion structure	8	11/66 - 3/67
7	Laguna St.	a_3	≥ 10	Outfall below diversion structure	2	3/67

a_1 - Pumped to sample bottle from intake on bottom of sewer. About 10 sec required to fill bottle.

a_2 - Mechanical sampler traverses flow from top to bottom over about a two minute interval. Provides depth integrated sample. Final sample composited from three samplers at outfall.

a_3 - Manual grab samples taken in sewer outfall.

Time synchronization: quality-flow good at all locations since both measurements made simultaneously at same point.

Table VII-24. Quality Parameters - San Francisco

Not all parameters are given for all storms at all catchments

Parameter	Catchment No.	STORET Code	Units
COD	All	340	mg/l
BOD_5	All	310	mg/l
Floatables	All	90055	mg/l
Grease (Hex Extract)	All	70351	mg/l
Set. Solids	1-5	545	ml/l
Set. Solids @ 30 min	6,7	90060	ml/l
Sus. Solids (SS)	All	530	mg/l
Vol. SS	All	535	mg/l
Particle Size Dist.			
% Retained on:			
74 μ filter	1-5	90065	%
14 μ filter	1-5	90066	%
5 μ filter	1-5	90067	%
0.45 μ filter	1-5	90068	%
Tot. N	1-5	600	mg/l-N
NH_3-N	All	610	mg/l-N
TKN	6,7	625	mg/l-N
OPO_4-P	1-5	70507	mg/l-P
TPO_4-PO_4	6,7	650	mg/l-PO_4
Tot. Colif.	1-5	31505	MPN/100 ml[a]
Fec. Colif.	All	31615	MPN/100 ml[a]
Spec. Conductivity	All	95	μ mho
Alkalinity	All	410	mg/l as $CaCO_3$
pH	1-5	400	
Bioassay	1-5	90069	% survival at 96 hrs
SO_4	6,7	945	mg/l-SO_4
Cl	6,7	940	mg/l
Na	6,7	929	mg/l
K	6,7	937	mg/l
Ca	6,7	916	mg/l
Mg	6,7	927	mg/l
Settled BOD	6	90064	mg/l
Vol. Set. Solids	6	544	mg/l
Settled COD	6	90063	mg/l
Toxicity	1-5	90070	% survival at 96 hrs
Flow	All	61	cfs
Rainfall	All	90050	in./hr

---

[a] On data tape, coliforms are given as 100 x $\log_{10}$ (MPN/100 ml).

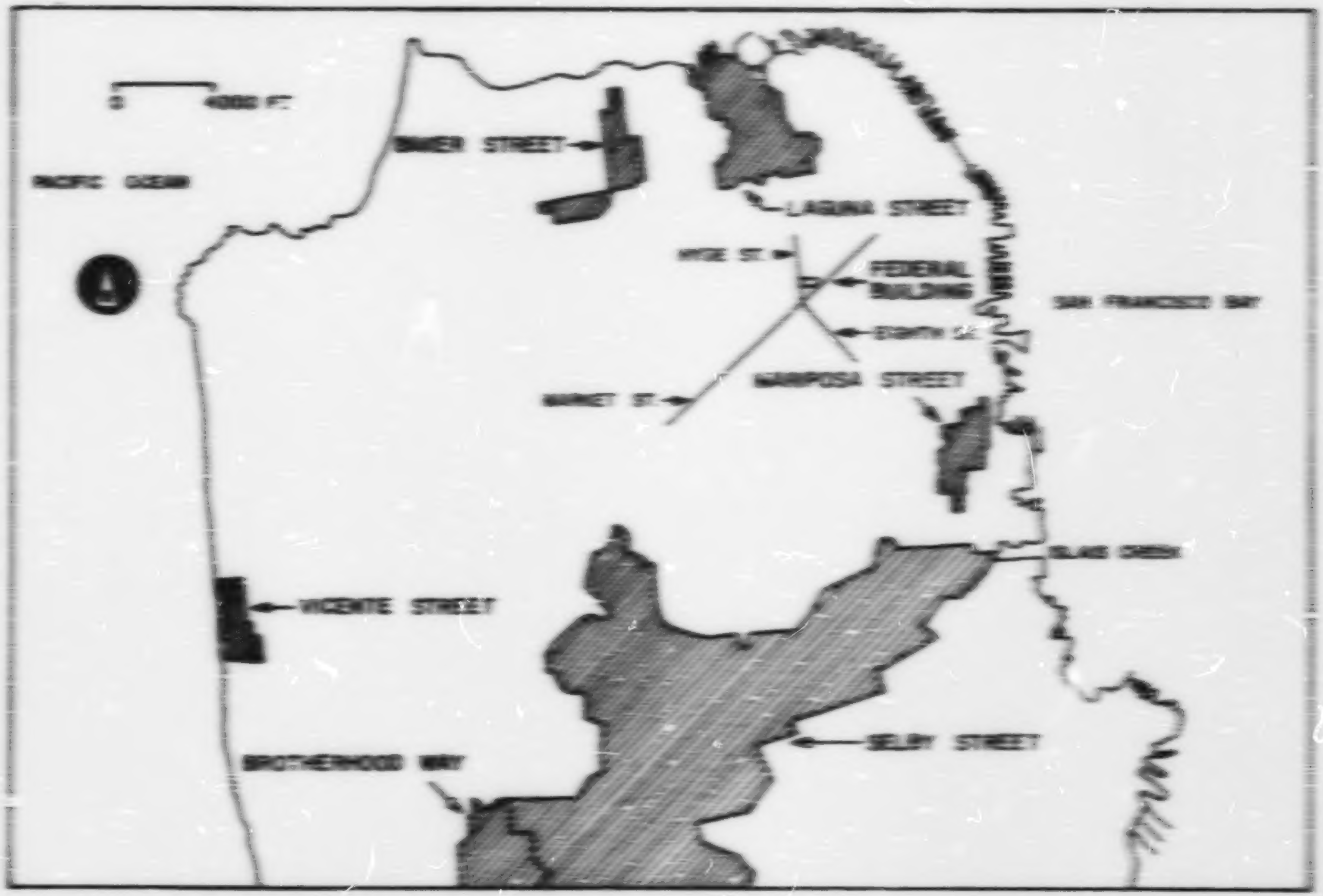

0 4000 FT.
PACIFIC OCEAN
BAKER STREET
LAGUNA STREET
HYDE ST.
FEDERAL BUILDING
SAN FRANCISCO BAY
EIGHTH ST.
MARIPOSA STREET
MARKET ST.
ISLAIS CREEK
VICENTE STREET
SELBY STREET
BROTHERHOOD WAY

Figure VII-10 Location map for San Francisco catchments.

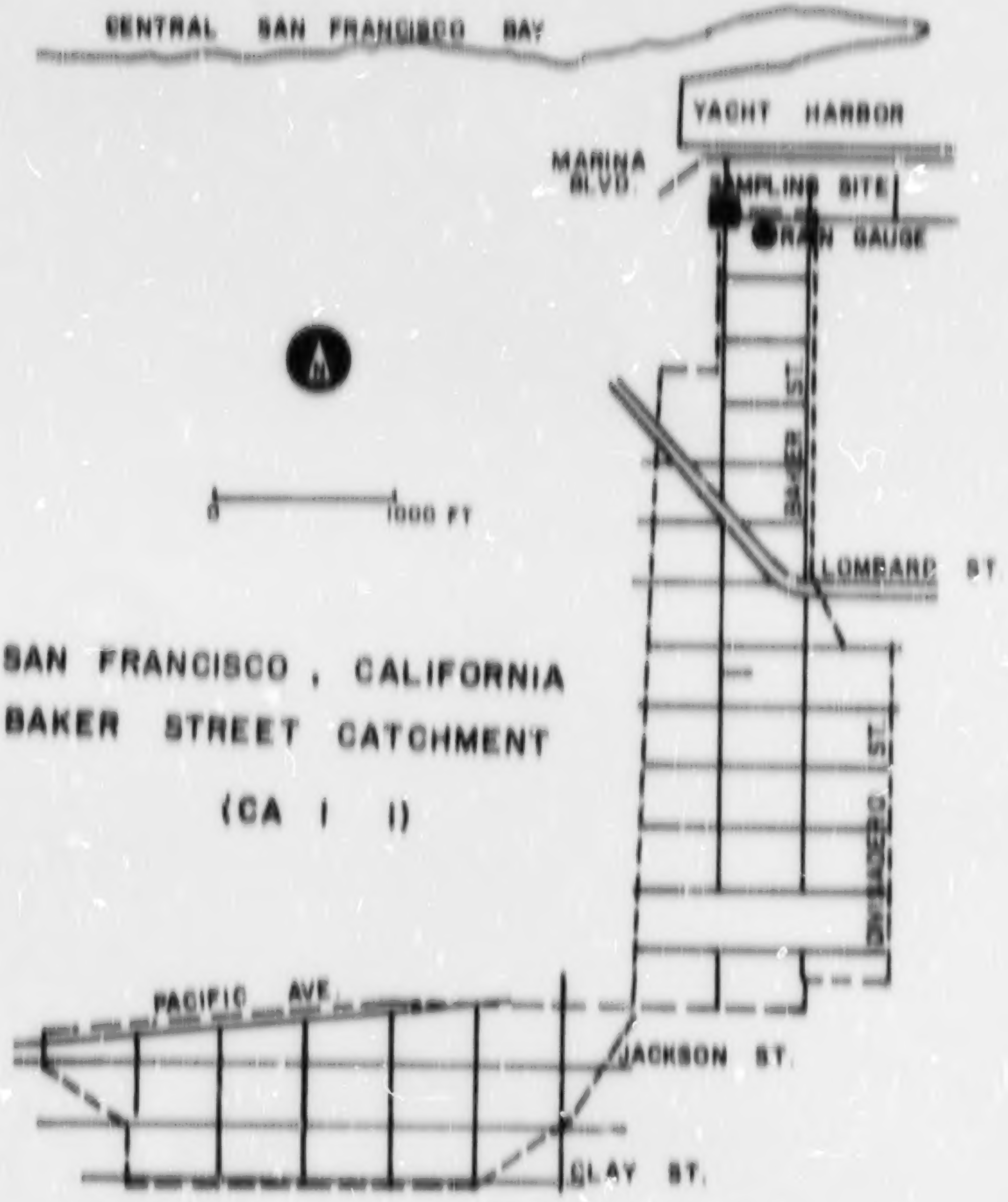

CENTRAL SAN FRANCISCO BAY
YACHT HARBOR
MARINA BLVD.
SAMPLING SITE
RAIN GAUGE
0
1000 FT
BAKER ST.
LOMBARD ST.
DIVISADERO ST.
SAN FRANCISCO, CALIFORNIA
BAKER STREET CATCHMENT
(CA I I)
PACIFIC AVE.
JACKSON ST.
CLAY ST.

Figure VII-11 San Francisco, California, Baker St. Catchment, 168 ac (68 ha)

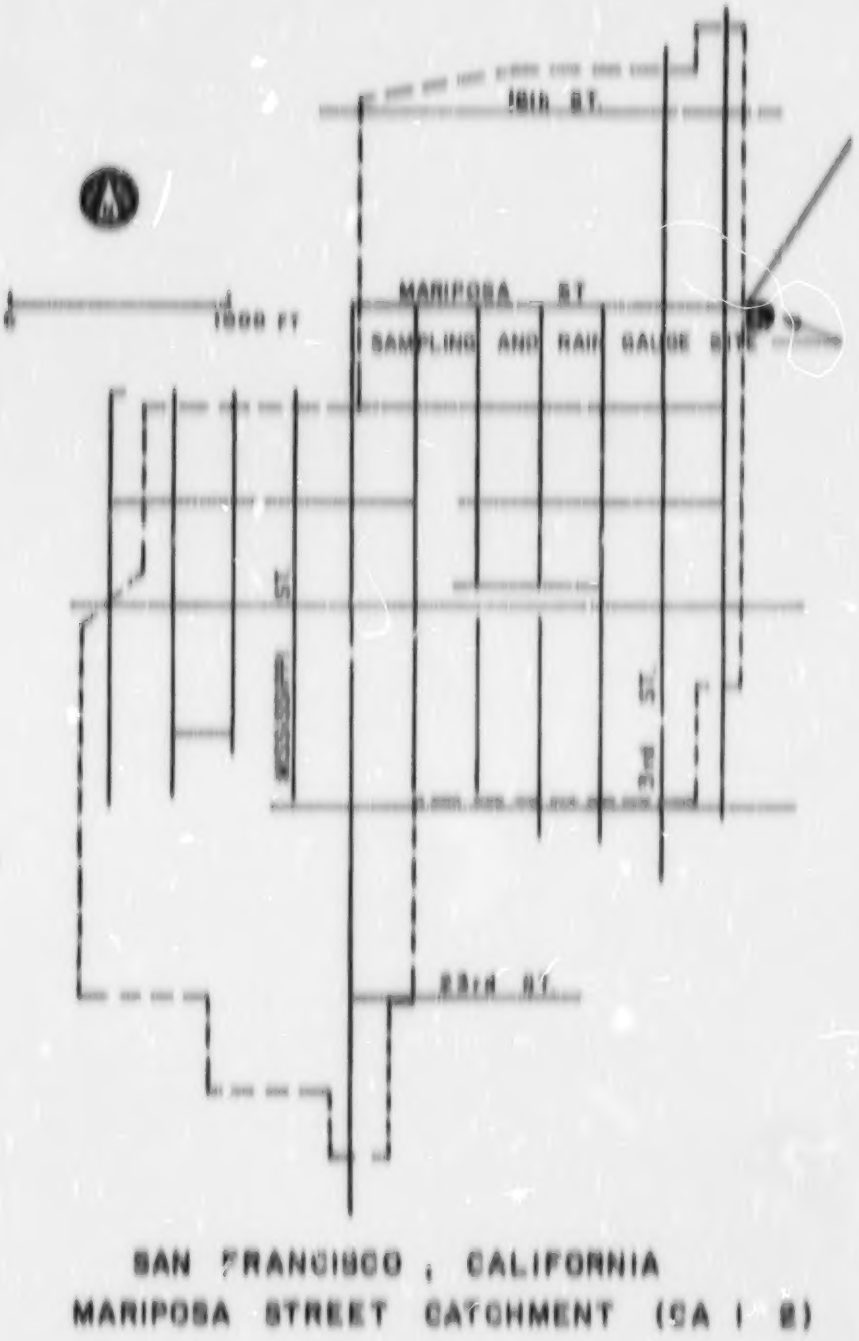
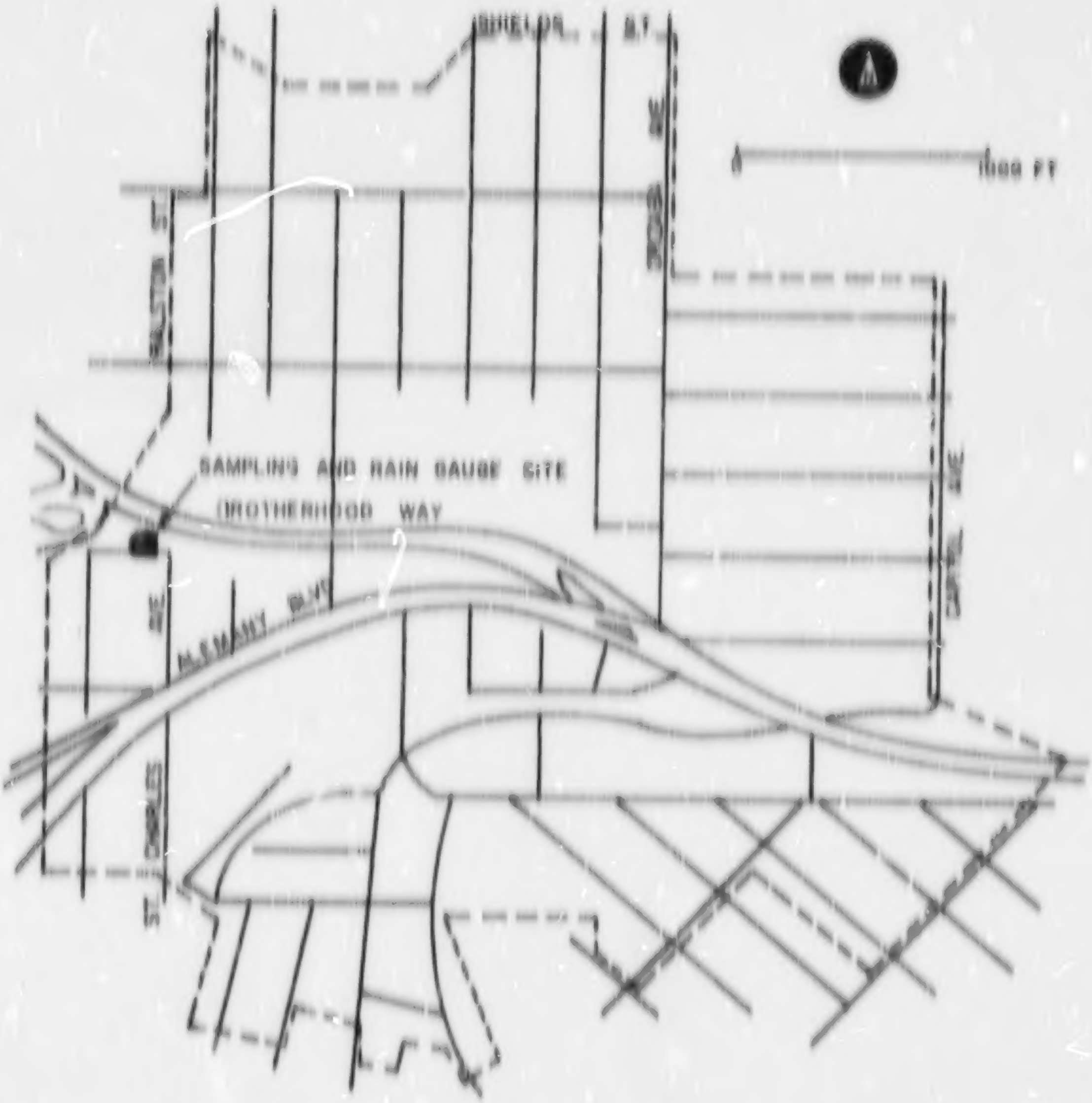

18th ST.
MARIPOSA ST
SAMPLING AND RAIN GAUGE SITE
0
1000 FT
ST.
3rd ST.
23rd ST.
SAN FRANCISCO , CALIFORNIA
MARIPOSA STREET CATCHMENT (CA 1 2)

Figure VII-12 San Francisco, California, Mariposa St. Catchment, 223 ac (90 ha)


SHIELDS ST
0
1000 FT
RALSTON ST
SAMPLING AND RAIN GAUGE SITE
BROTHERHOOD WAY
ALEMANY BLVD
AVE
CAPITOL AVE
ST. CHARLES AVE

SAN FRANCISCO, CALIFORNIA
BROTHERHOOD WAY CATCHMENT (CA I 3)

Figure VII-13 San Francisco, California, Brotherhood Way Catchment, 180 ac (73 ha).

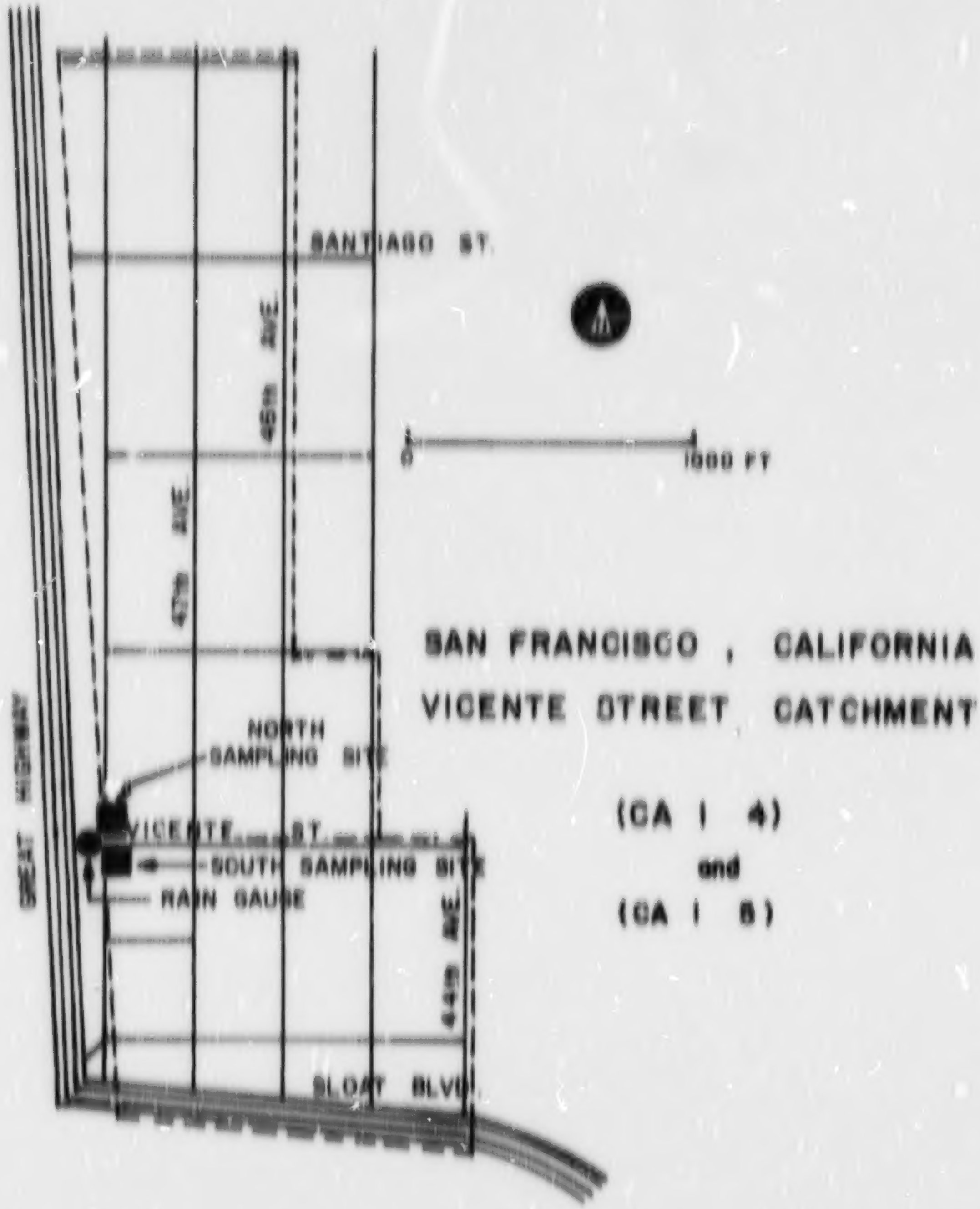

SANTIAGO ST.
46th AVE
0
1000 FT
47th AVE
SAN FRANCISCO , CALIFORNIA
VICENTE STREET CATCHMENT
(CA I 4)
and
(CA I 5)
GREAT HIGHWAY
NORTH SAMPLING SITE
VICENTE ST.
SOUTH SAMPLING SITE
RAIN GAUGE
44th AVE
SLOAT BLVD.

Figure VII-14 San Francisco, California, Vicente St. North Catchment, 16 ac (6.5 ha) and Vicente St. South Catchment, 21 ac (8.5 ha).

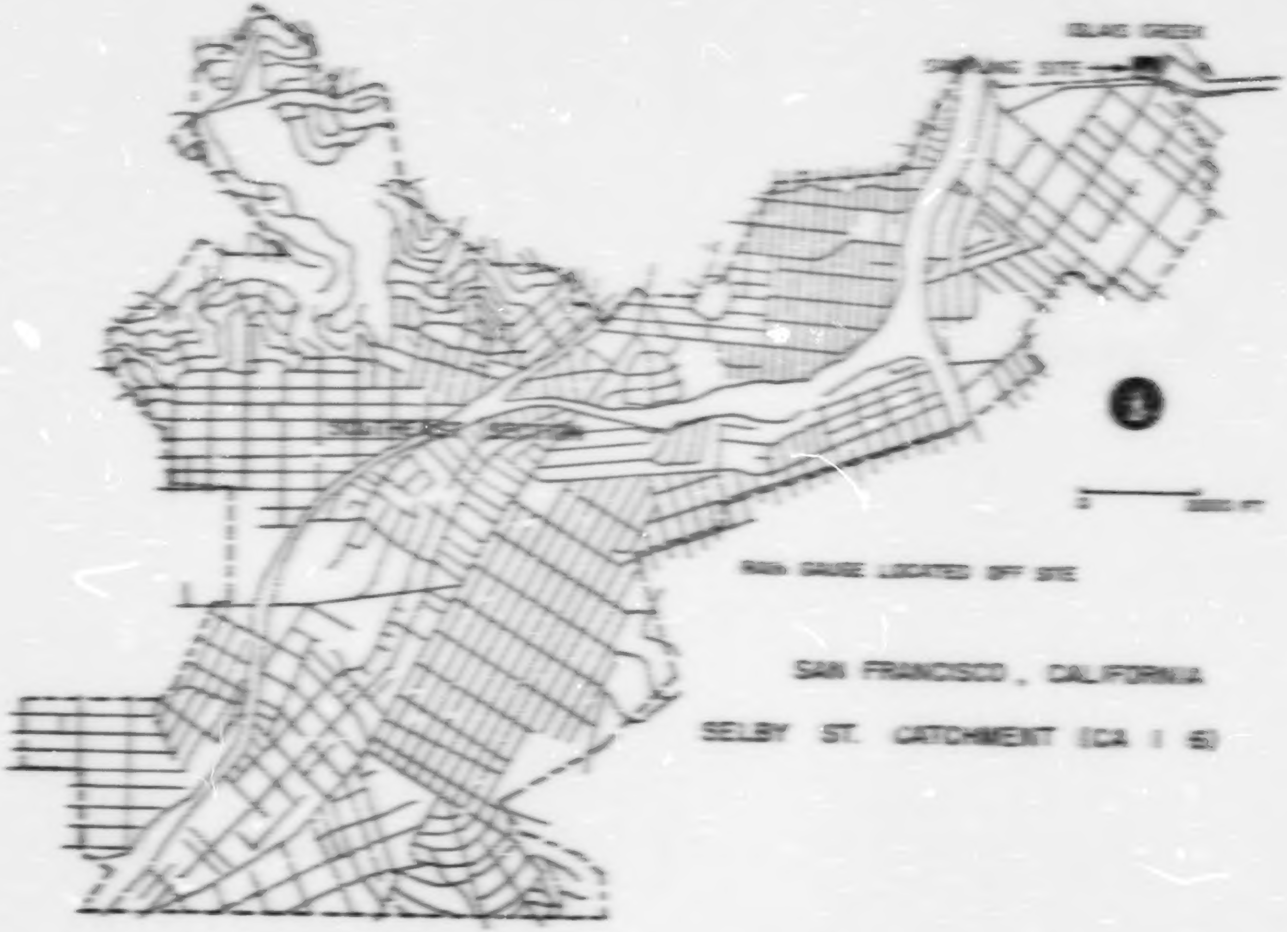

ISLAIS CREEK
SAMPLING SITE
SOUTHERN FREEWAY
0
2000 FT
RAIN GAUGE LOCATED OFF SITE
SAN FRANCISCO, CALIFORNIA
SELBY ST. CATCHMENT (CA 1 6)

Figure VII-15 San Francisco, California, Selby St. Catchment, 3400 ac (1380 ha).

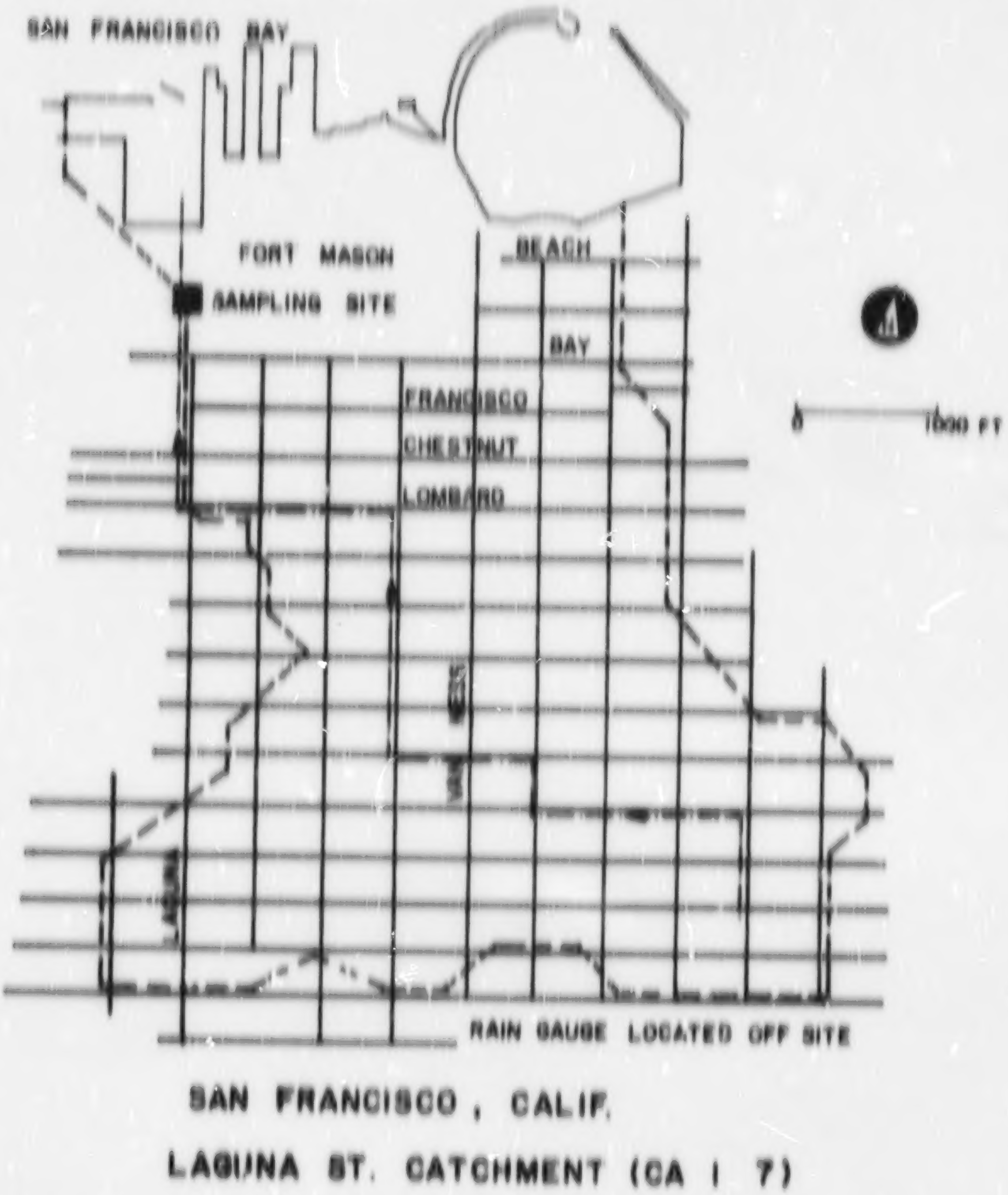

SAN FRANCISCO BAY
FORT MASON
SAMPLING SITE
BEACH
BAY
FRANCISCO
CHESTNUT
LOMBARD
LAGUNA
0
1000 FT
RAIN GAUGE LOCATED OFF SITE
SAN FRANCISCO, CALIF.
LAGUNA ST. CATCHMENT (CA I 7)

Figure VII-16 San Francisco, California, Laguna St. Catchment, 375 ac (152 ha).

SEATTLE, WASHINGTON

The data included in this report were made available by the Municipality of Metropolitan Seattle (METRO) through the River Basin Coordinating Committee, plus later data through a continuing sampling program by METRO. The data are part of an integrated study of water and wastewater management of the Cedar and Green River Basins (33, 146).

Seven catchments were sampled representing residential, commercial, and industrial land use. Data for all seven were gathered during 1973 under a cooperative arrangement between METRO and the Seattle District Corps of Engineers. Intensive sampling at three catchments has continued into 1974-75. All data, with the exception of some limited 74-75 rainfall data, were reduced by the agency prior to receipt by UF.

All Seattle data are considered excellent, both in terms of sampling procedures and volume. METRO personnel are performing extensive in-house analyses of the data to determine loading rates, statistical parameters, etc. When published, their reports should provide a valuable addition to the data themselves. Some additional information on the catchments is available in modeling studies performed for the city (109, 143).

State and City Code: WA 01

Table VII-25. Catchments - Seattle

No.	Name	Area ac (ha)	Sewerage	Land Use
1	View Ridge 1 (VR1)[a]	630 (255)	Storm	High dens., older single family residential
2	View Ridge 2 (VR2)	105 (43)	Storm	Single fam. res. 50%, multiple fam. res. 40%, com. and hosp. 10%
3	South Seattle (SE3)	27.5 (11.1)	Storm	Industrial
4	Southcenter (SC4)	24 (9.8)	Storm	New shopping center (com.)
5	Lake Hills (LH5)	150 (61)	Storm	Medium dens., newer single family residential
6	Highlands (HL6)	85 (34)	Storm	Low density, wooded, single family residential
7	Central Bus. Dist. (CBD7)	27.8 (11.3)	Combined	Older business district (com.)

---

[a] Notation used in Seattle documentation.

Table VII-26. Quantity Data - Seattle

		Flow		Rain					
				Gages Used					
No.	Catchment	Type of Flow Meas[a]	Sampling Interval[b] min	No. in Catchment	No. near Catchment	Type	Sampling Interval min	No. Storms	Period
1	View Ridge 1	f_1	5-15	0	3	r_1	5-60	5 25	3/73- 9/73 10/74-12/75
2	View Ridge 2	f_3	5-15	1	2	r_1	5-15	5	3/73- 9/73
3	South Seattle	f_3	5-15	0	2	r_1	5-60	5 26	3/73- 9/73 10/74-12/75
4	Southcenter	f_1	5-15	1	0	r_1	5-60	6 25	3/73- 9/73 10/74-12/75
5	Lake Hills	f_2	5-15	1	1	r_1	5-15	5 2	3/73- 9/73 4/75- 6/75
6	Highlands	f_3	5-15	0	1	r_1	5-15	4	3/73- 9/73
7	Central Bus. Dist.	f_3	5-15	0	1	r_1	5-15	5	3/73- 9/73

---

[a] All flows computed from stage-discharge relationship from Manning equation, with some calibration using velocity measurements. Stage measured by Action Model 67 TB Nitrogen Gas Bubbler Tube.

f_1 - Recorder at hole in conduit. f_2 - Recorder at catchbasin. f_3 - Recorder at manhole.

[b] Flows were calculated every 15 min from strip chart records with linear interpolation for values reported at shorter intervals.

r_1 - Stevens tipping bucket gage and event recorder. Reported data are for gage in catchment, if working, or else nearest gage in direction of approaching storm.

Time synchronization, rain-flow: dependent upon separate clocks in rain and stage gages.
No problems reported.

Comment: Early problems in flow measurements developed at Southcenter, Lake Hills and Highlands due to unusually high velocities creating a venturi effect as water rushed past the bubbler tube. Weirs were installed on April 23-24, 1973 to reduce velocities, and calibrations changed accordingly. Flow data are considered very good, in general.

Table VII-27. Quality Sampling - Seattle

No.	Catchment	Sampling Method	Sampling Interval, min	Sampling Location	No. Storms	Period
1	View Ridge 1	a_1	15	Flow-measuring site	5 25	2/73- 9/73 10/74-12/75
2	View Ridge 2	a_2	15	Flow-measuring site	5	3/73- 9/73
3	South Seattle	a_1	15	Flow-measuring site	5 26	3/73- 9/73 10/74-12/75
4	Southcenter	a_1	15	Flow-measuring site	5 25	2/73- 9/73 10/74-12/75
5	Lake Hills	a_2	15	Flow-measuring site	5 2[a]	3/73- 9/73 4/75- 6/75
6	Highlands	a_2	15	Flow-measuring site	4	3/73- 9/73
7	Central Bus. Dist.	a_2	15	Flow-measuring site	5	3/73- 9/73

---

[a] Only quality data are a few measurements of total P.

a_1 – Manual grab samples in 2 gal (7.6 l) bottles (1973 storms). Most 1974-75 storms used Serco automatic samplers.

a_2 – Manual grab samples in 2 gal (7.6 l) bottles.

Time synchronization, flow-quality: good since flow measured at same location as quality sampling.

Table VII-28. Quality Parameters - Seattle

Not all parameters are given for all storms at all catchments.

Parameter	Catchment No.	STORET Code	Units
DO	All	300	mg/l
pH	All	400	
Temperature	All	10	°C
Susp. Solids (SS)	All[a]	530	mg/l
BOD_5	All	310	mg/l
COD	All	340	mg/l
Cd	All[a]	1027	μg/l
Cr	All	1034	μg/l
Cu	All	1042	μg/l
Pb	All[a]	1051	μg/l
Zn	All[a]	1092	μg/l
Cl	All	940	mg/l
NH_3-N	All[a]	610	mg/l-N
NO_2-N	All	615	mg/l-N
NO_2-N + NO_3-N	All[a]	630	mg/l-N
TKN	All	625	mg/l-N
Organic-N	1,3,4[a]	605	mg/l-N
Fec. Colif.	All	31616	MPN/100 ml[b]
Tot. Colif.	All	31501	MPN/100 ml[b]
Tot. Hydrolis. P	All	669	mg/l-P
Tot. P	1,3,4[a]	665	mg/l-P
OPO_4-P	All[a]	70507	mg/l-P
Conductivity	All[a]	94	μ mho/cm
Turbidity	All[a]	70	JTU
Grease (Hex Extract)	All	70351	mg/l
Tot. Dis. Solids	All	515	mg/l
Set. Solids (at 1 hr)	All	546	mg/l
SO_4	All	945	mg/l
Fe	All	1045	μg/l
Hg	All	7190	μg/l
As	All	1002	μg/l
Flow	All[a]	61	cfs
Rain	All[a]	90050	in./hr
Dry Days Preceding Storm[c]	1,3,4	90100	days
Catchment Area[c]	1,3,4	53	acres
Storm Rainfall[c]	1,3,4	45	in.

---

[a] Only parameters measured when using automatic samplers during 1974-75 storms

[b] On data tape, coliforms are given as 100 x $\log_{10}$ (MPN/100 ml).

[c] Also provided on data tape for 1974-75 storms.

Table VII-29. Background Levels at Three Catchments - Seattle

Limited samples were taken in 1976 to determine background levels of parameters during periods of no rain. These may be used as initial conditions at the initiation of storms. They also are subject to refinement at a future date.

Parameter	STORET Code	Concentration at Catchments 1 (VR1)	 3 (SS3)	 4 (SC4)	Units
Tot. P	665	0.15	0.11	0.22	mg/l-P
OPO_4-P	70507	0.09	0.1	0.14	mg/l-P
Organic-N	605	0.44	0.40	0.80	mg/l-N
NH_3-N	610	0.06	0.08	0.16	mg/l-N
NO_2 + NO_3-N	630	2.3	0.1	0.35	mg/l-N
Susp. Solids (SS)	530	6.0	24.0	14.0	mg/l
Turbidity	70	120	220	110	JTU
Conductivity	94	290	180	420	µ mho/cm
Cd	1027	4[a]	4[a]	4[a]	µg/l
Pb	1051	100	100	100	µg/l
Zn	1092	10	190	150	µg/l
Flow	61	0.24	0.01	0.01	cfs

---

[a] Lowest measureable.

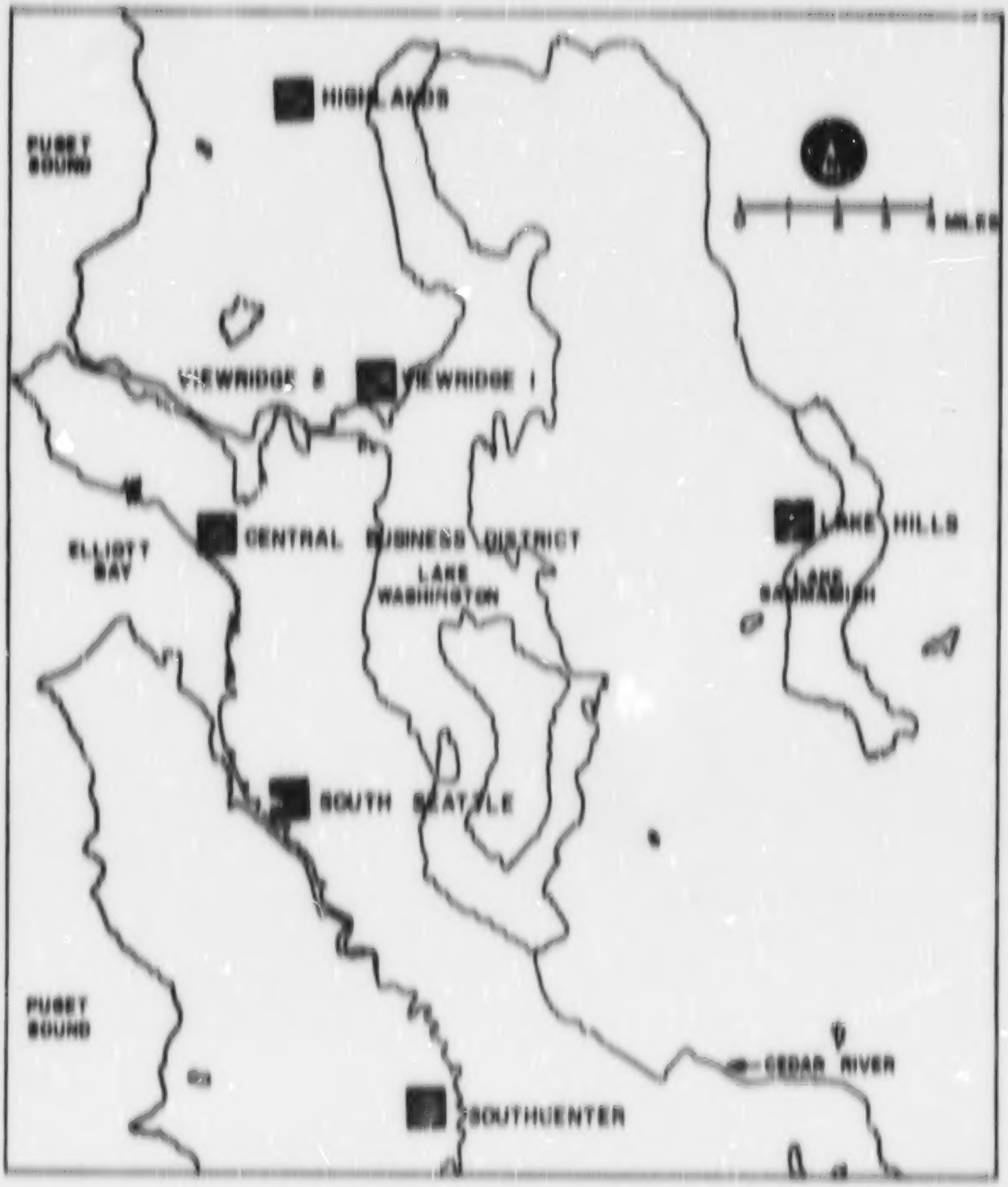

PUGET SOUND
HIGHLANDS
0 1 2 3 4 MILES
VIEWRIDGE 2
VIEWRIDGE 1
ELLIOTT BAY
CENTRAL BUSINESS DISTRICT
LAKE WASHINGTON
LAKE HILLS
LAKE SAMMAMISH
SOUTH SEATTLE
PUGET SOUND
CEDAR RIVER
SOUTHCENTER

Figure VII-17 Location map for Seattle catchments.

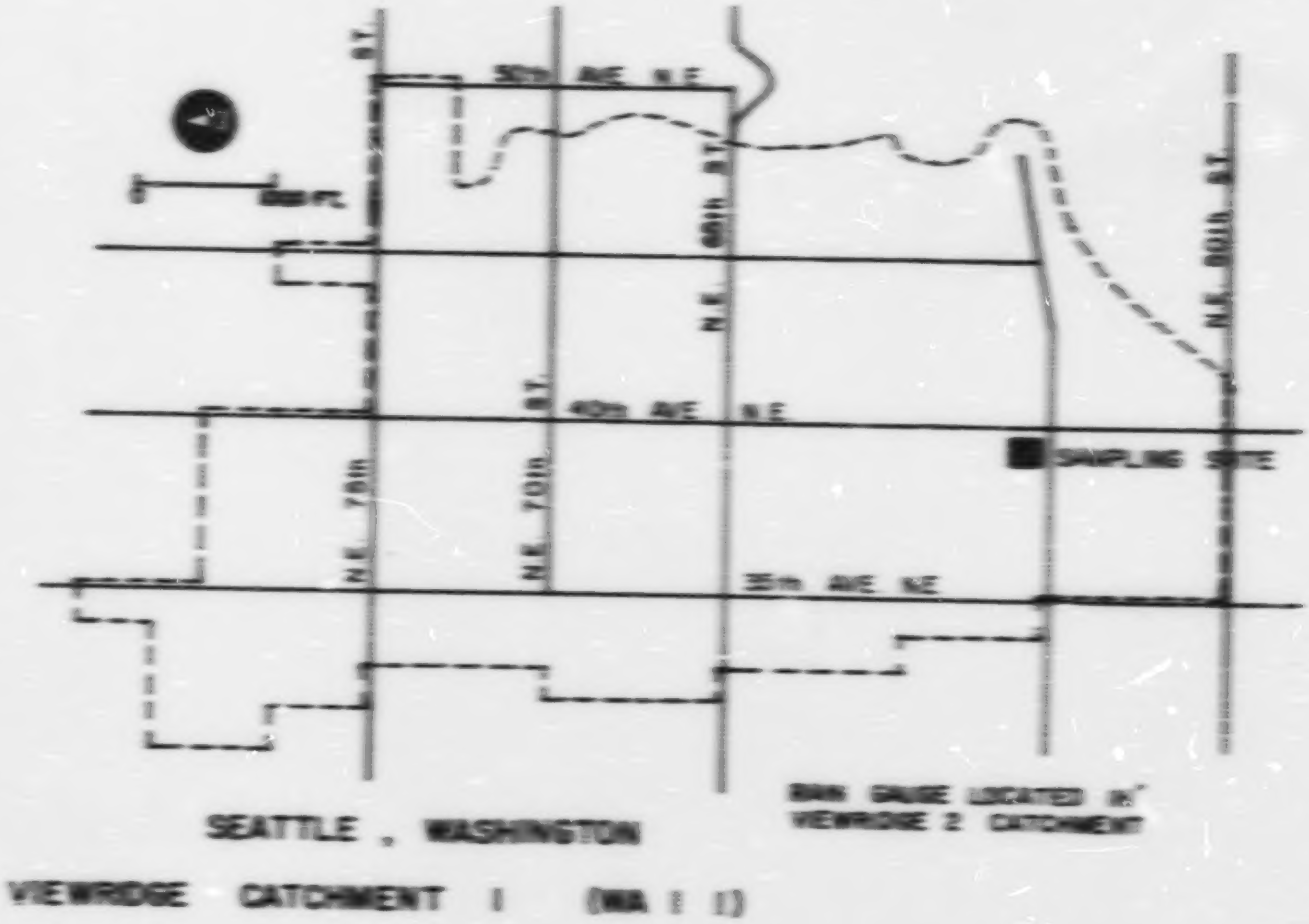

N.E. 75th ST.
50th AVE N.E.
0
500 FT.
N.E. 70th ST.
N.E. 65th ST.
40th AVE N.E.
N.E. 60th ST.
SAMPLING SITE
35th AVE NE
RAIN GAUGE LOCATED in
VIEWRIDGE 2 CATCHMENT
SEATTLE , WASHINGTON
VIEWRIDGE CATCHMENT 1 (WA : 1)

Figure VII-18 Seattle, Washington, Viewridge 1 Catchment, 630 ac (255 ha).

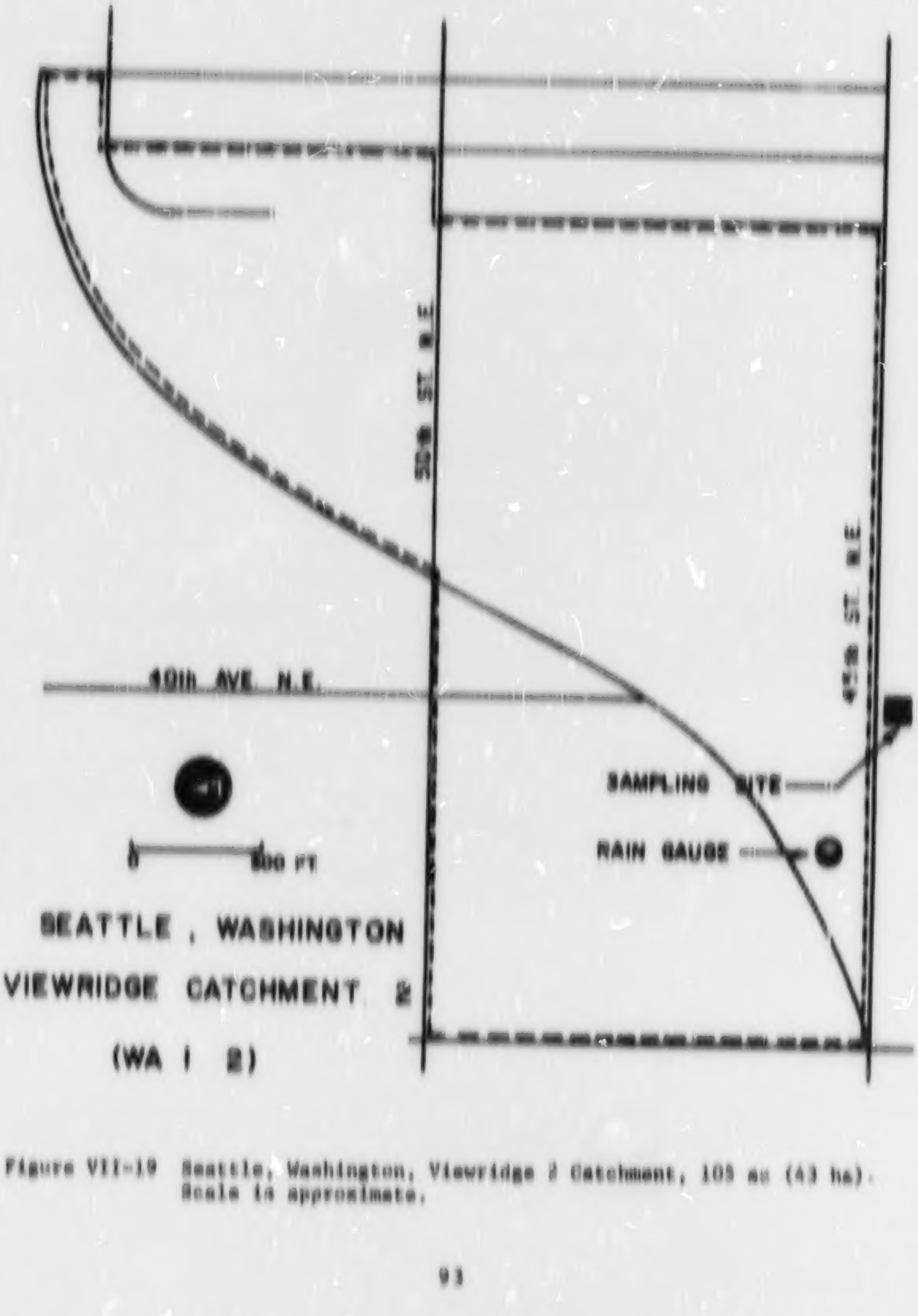
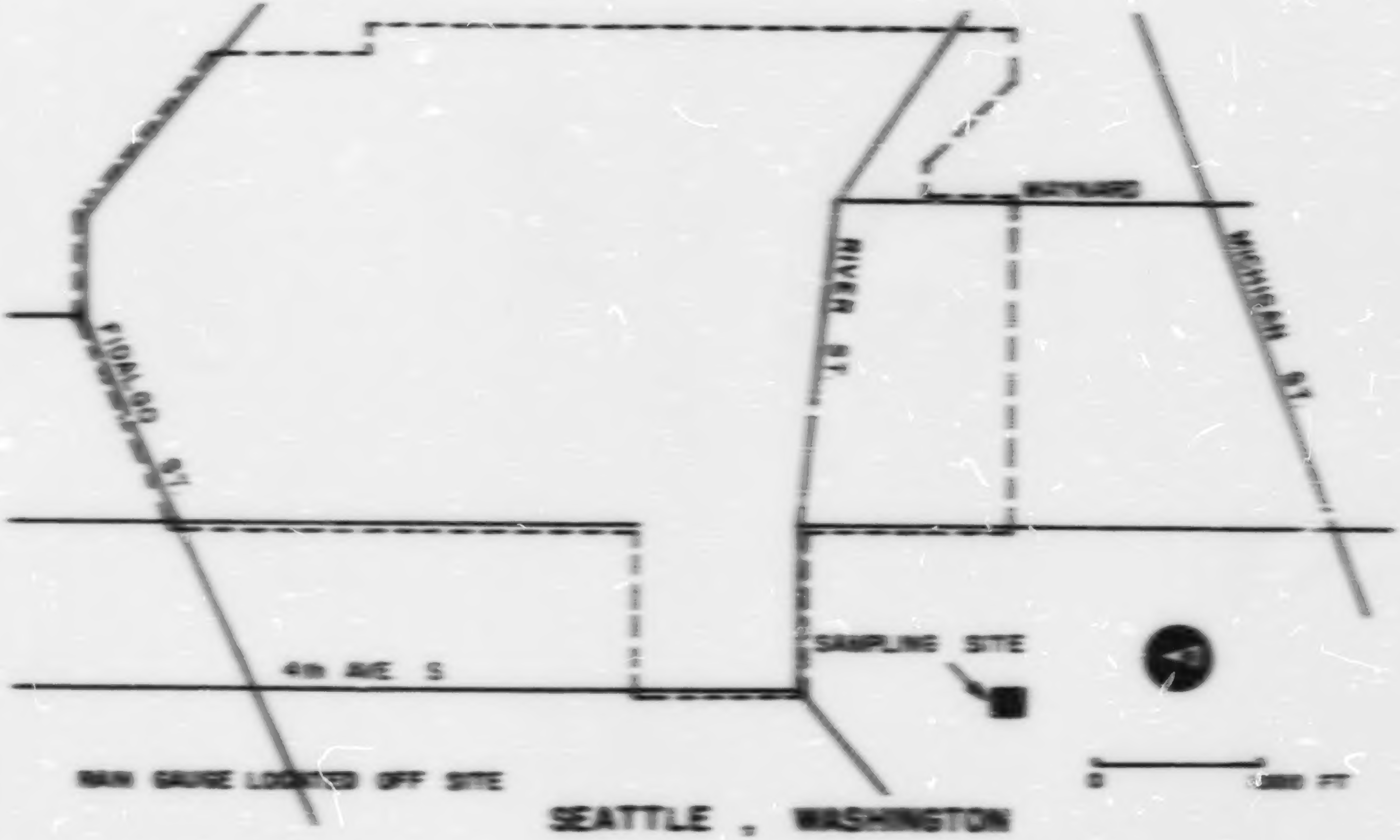

50th ST. N.E.
45th ST. N.E.
40th AVE. N.E.
SAMPLING SITE
RAIN GAUGE
0
500 FT
SEATTLE , WASHINGTON
VIEWRIDGE CATCHMENT 2
(WA I 2)

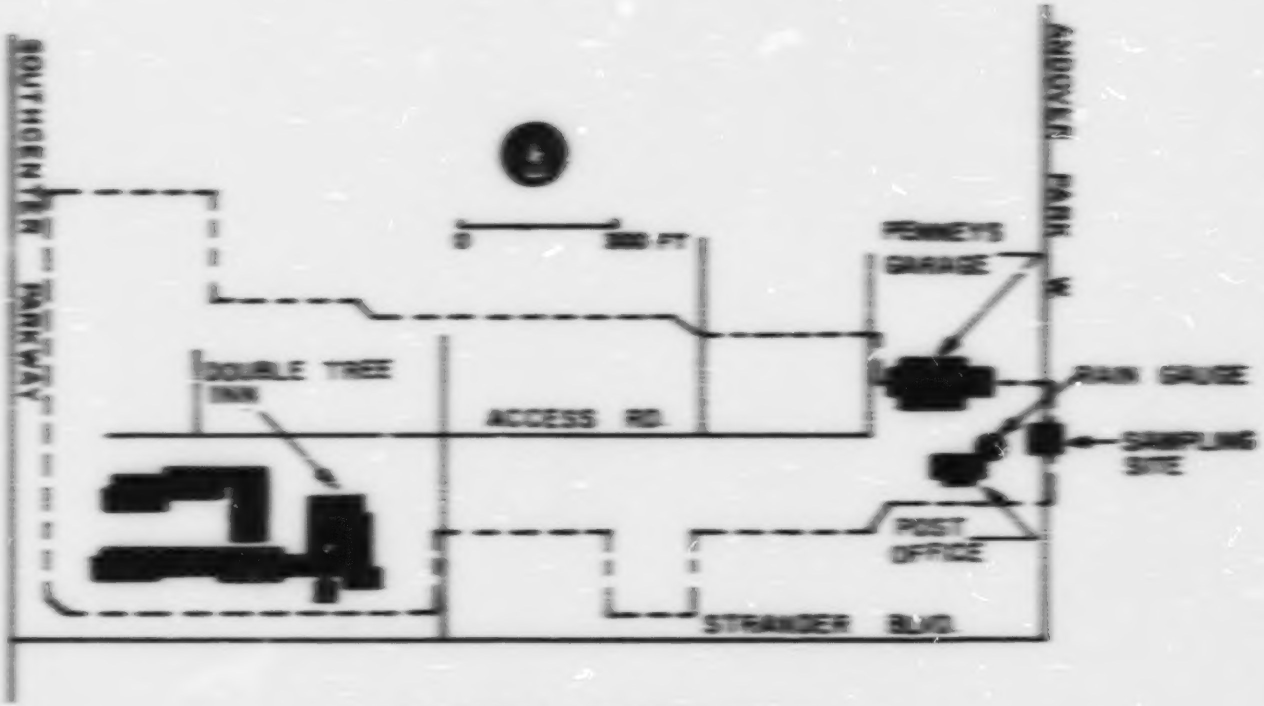
Figure VII-19 Seattle, Washington, Viewridge 2 Catchment, 105 ac (43 ha). Scale is approximate.


MICHIGAN ST.
HAYWARD
RIVER ST.
FIDALGO ST.
4th AVE. S
SAMPLING SITE
RAIN GAUGE LOCATED OFF SITE
0
1000 FT

SEATTLE, WASHINGTON

SOUTH SEATTLE CATCHMENT (WA 1 3)

Figure VII-23 Seattle, Washington, South Seattle Catchment, 27.5 ac (11.1 ha).


SOUTHCENTER PARKWAY
ANDOVER PARK W.
0
300 FT
PENNEYS GARAGE
RAIN GAUGE
SAMPLING SITE
POST OFFICE
STRANDER BLVD.
ACCESS RD.
DOUBLE TREE INN

SEATTLE , WASHINGTON

SOUTHCENTER CATCHMENT (WA : 4)

Figure VII-21 Seattle, Washington, Southcenter Catchment, 24 ac (9.8 ha).

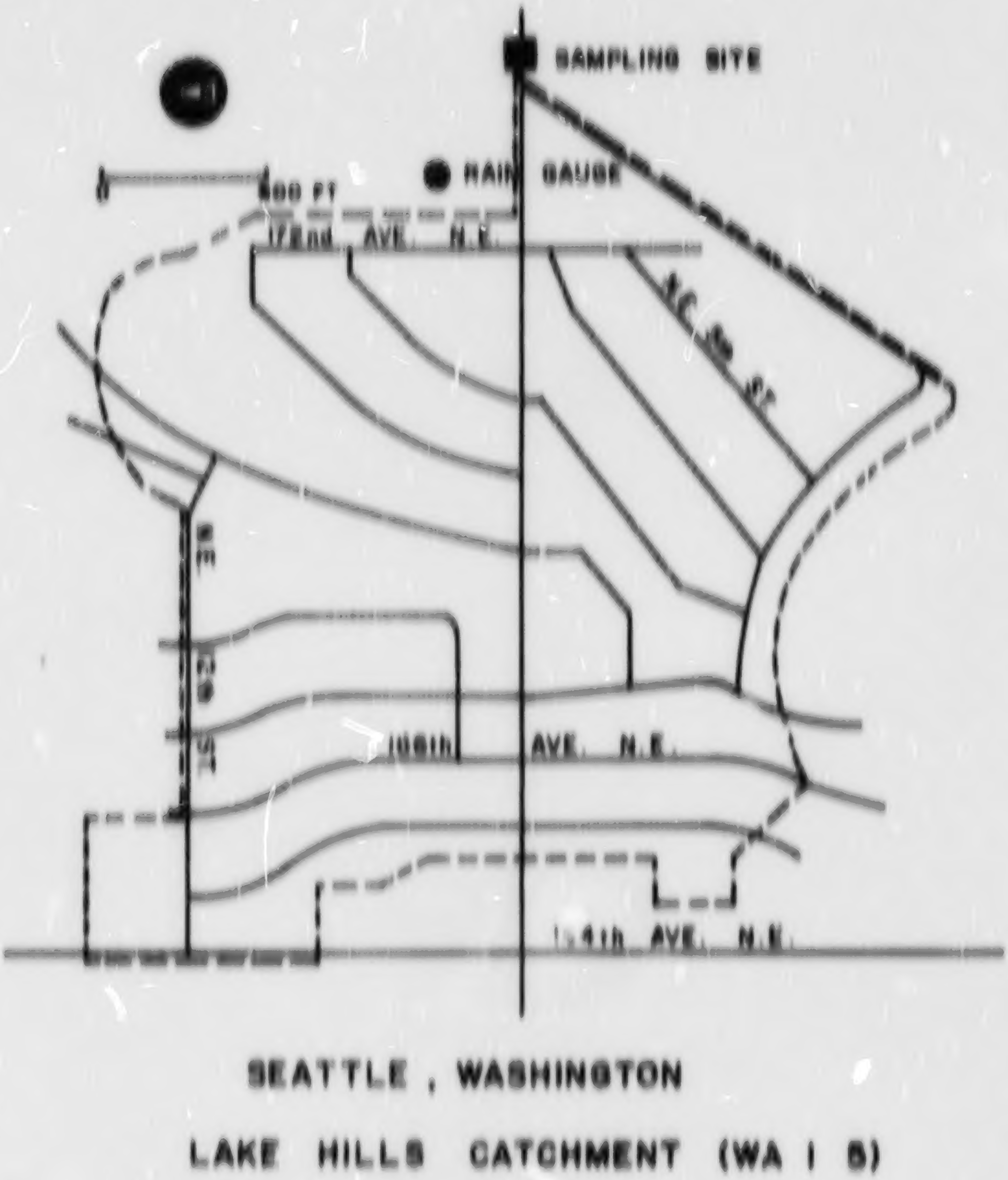
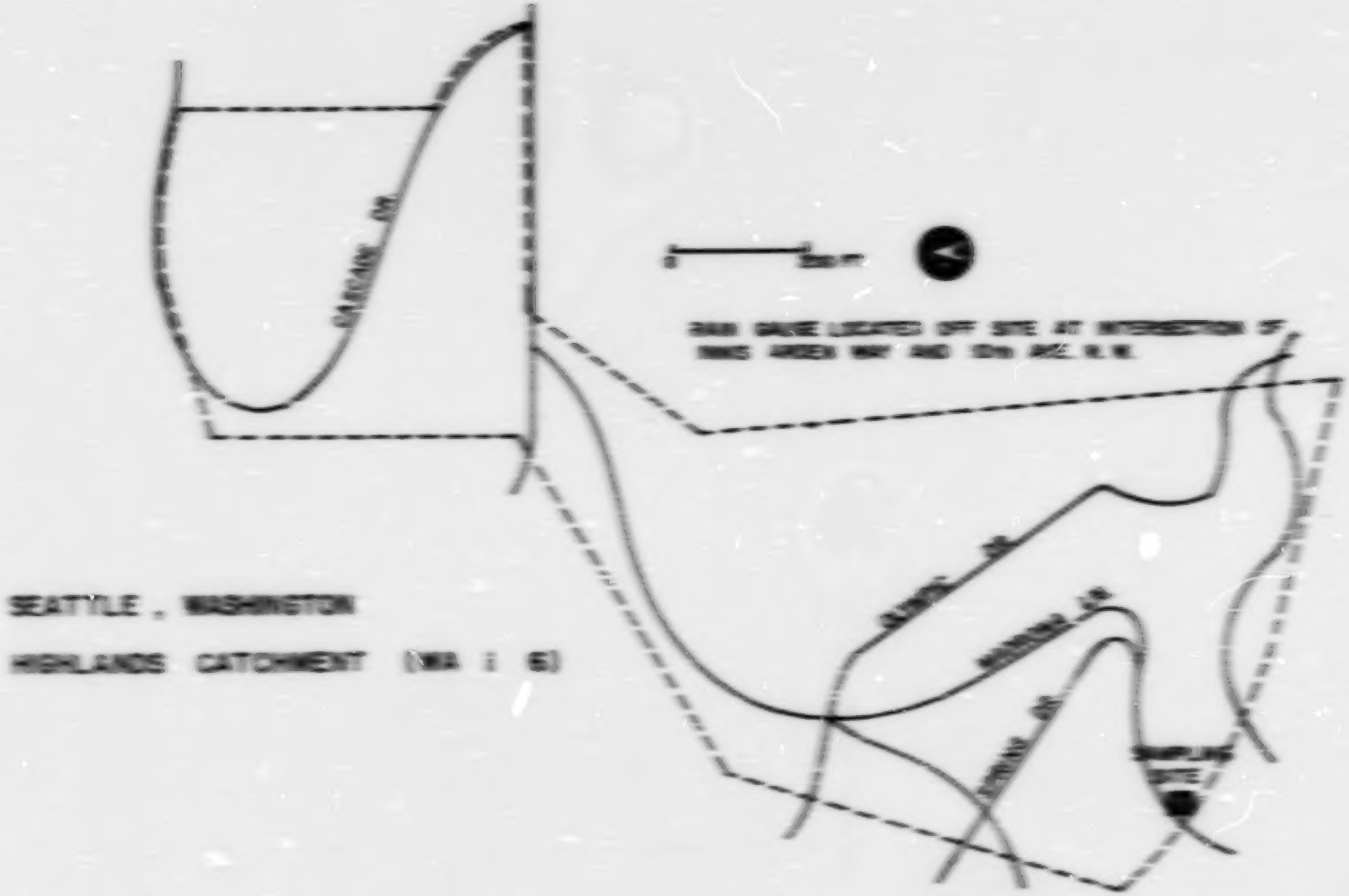

SAMPLING SITE
RAIN GAUGE
0
500 FT
172nd AVE. N.E.
N.E. 8th ST
SE
ST
168th AVE. N.E.
164th AVE. N.E.
SEATTLE , WASHINGTON
LAKE HILLS CATCHMENT (WA I 5)

Figure VII-22 Seattle, Washington, Lake Hills Catchment, 150 ac (61 ha).



CASCADE DR
0
250 FT
RAIN GAUGE LOCATED OFF SITE AT INTERSECTION OF [illegible] ARDEN WAY AND 15th AVE. N.W.
SAMPLING SITE
SEATTLE, WASHINGTON
HIGHLANDS CATCHMENT (WA : 6)

Figure VII-23 Seattle, Washington, Highlands Catchment, 85 ac (34 ha).

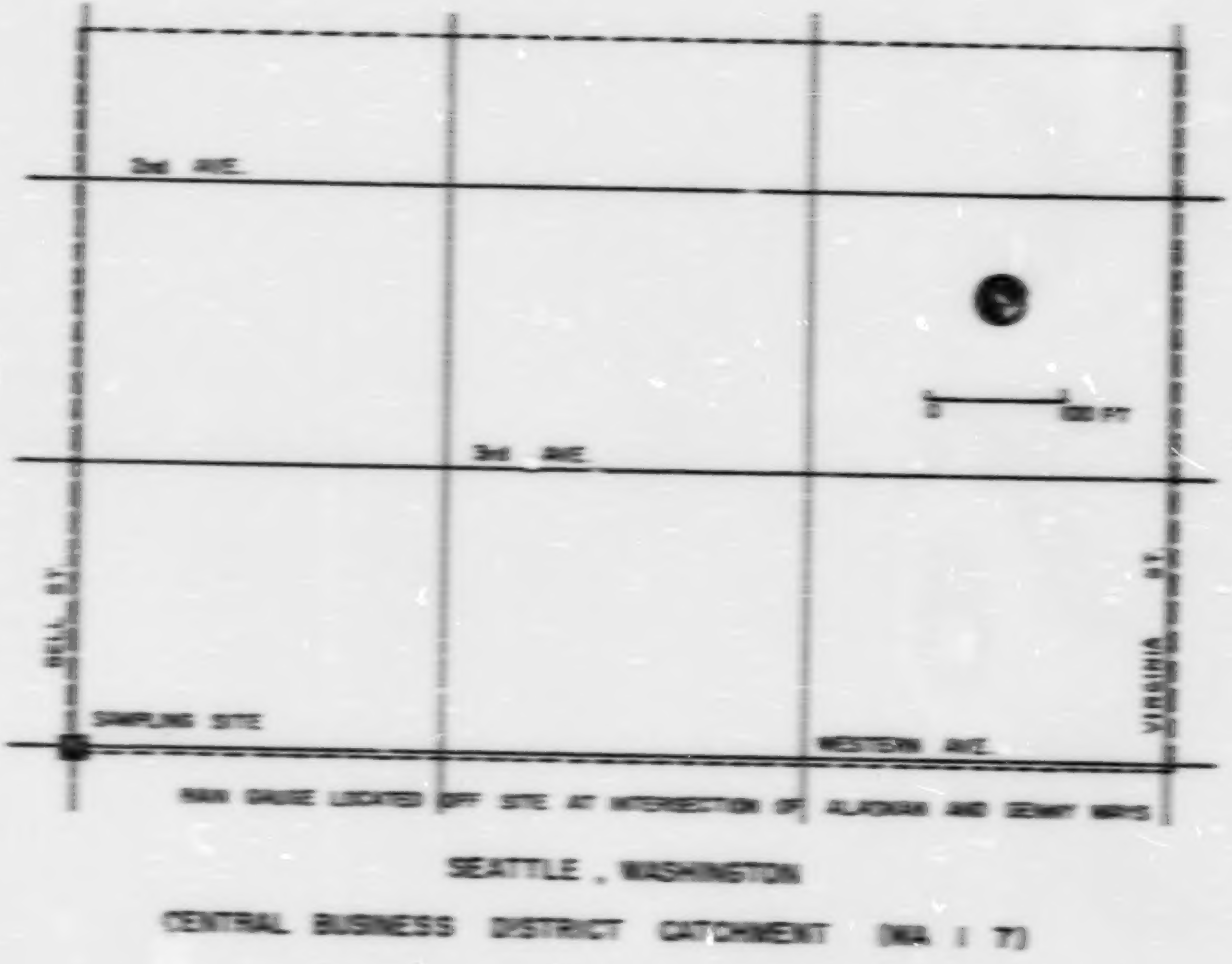

2nd AVE.
3rd AVE.
0
100 FT
BELL ST.
VIRGINIA ST.
SAMPLING SITE
WESTERN AVE.
RAIN GAUGE LOCATED OFF SITE AT INTERSECTION OF ALASKAN AND DENNY WAYS
SEATTLE, WASHINGTON
CENTRAL BUSINESS DISTRICT CATCHMENT (WA I T)

Figure VII-26 Seattle, Washington, Central Business District Catchment, 27.9 ac (11.3 ha).

WINDSOR, ONTARIO

Data were taken from the thesis of Droste (110) of the University of Windsor from one residential catchment for the period September 1972 to August 1973. Sampling and all data reduction were performed by the University of Windsor. Additional information about a nearby catchment is provided in an earlier study by Singh, but his data are not included because of construction activities underway during his sampling activities (111).

The data included herein were taken for a large number of storms, 22, but suffer from a large sampling interval of one hour. This will limit their usefulness somewhat for modeling purposes.

Province and City Code: ON 01

Table VIII-30. Catchment - Windsor

No.	Name	Area ac (ha)	Sewerage	Population	Land Use
1	Labadie Road	29.5 (11.9)	Storm	590	Single Family Residential

Table VIII-31. Quantity Data - Windsor

		Flow		Rain					
				Gages Used					
No.	Catchment	Type of Flow Meas	Sampling Interval min	No. in Catchment	No. near Catchment	Type	Sampling Interval min	No. Storms	Period
1	Labadie Road	f_1	60		3	r_1	60	22	9/72 - 8/73

---

f_1 - Stage measured by Arkon Model 63 TN Nitrogen Gas Bubbler Tube in 21 in. (53 cm) sewer at manhole. Flow computed using calibrated stage-discharge relationship.

r_1 - Not reported, but 0.01 in. (0.254 mm) accuracy.

Flow-rain synchronization: dependent upon separate clocks on rain and stage gages. No problems reported.

Comment: A weighted average of two or three rain gages is reported leading to some smoothing of data. Gages are operated by Department of Geography at University of Windsor. Storms of January 23-24, March 16-17, 1973 and November 25-26, 1972 contain significant snowfall.

Table VII-32. Quality Sampling - Windsor

Catchment	Sampling Method	Sampling Interval min	Sampling Location	No. Storms	Period
Labadie Road	a_1	60	Manhole	22	9/72 - 8/73

---

a_1 - Automatic grab sampler by Testing Machines International. Sampling head anchored to bottom of sewer. Samples not taken when flow < 0.01 cfs (0.28 l/sec).

Time synchronization: Quality-flow good because measurements taken at same location.

Table VII-33. Quality Parameters - Windsor

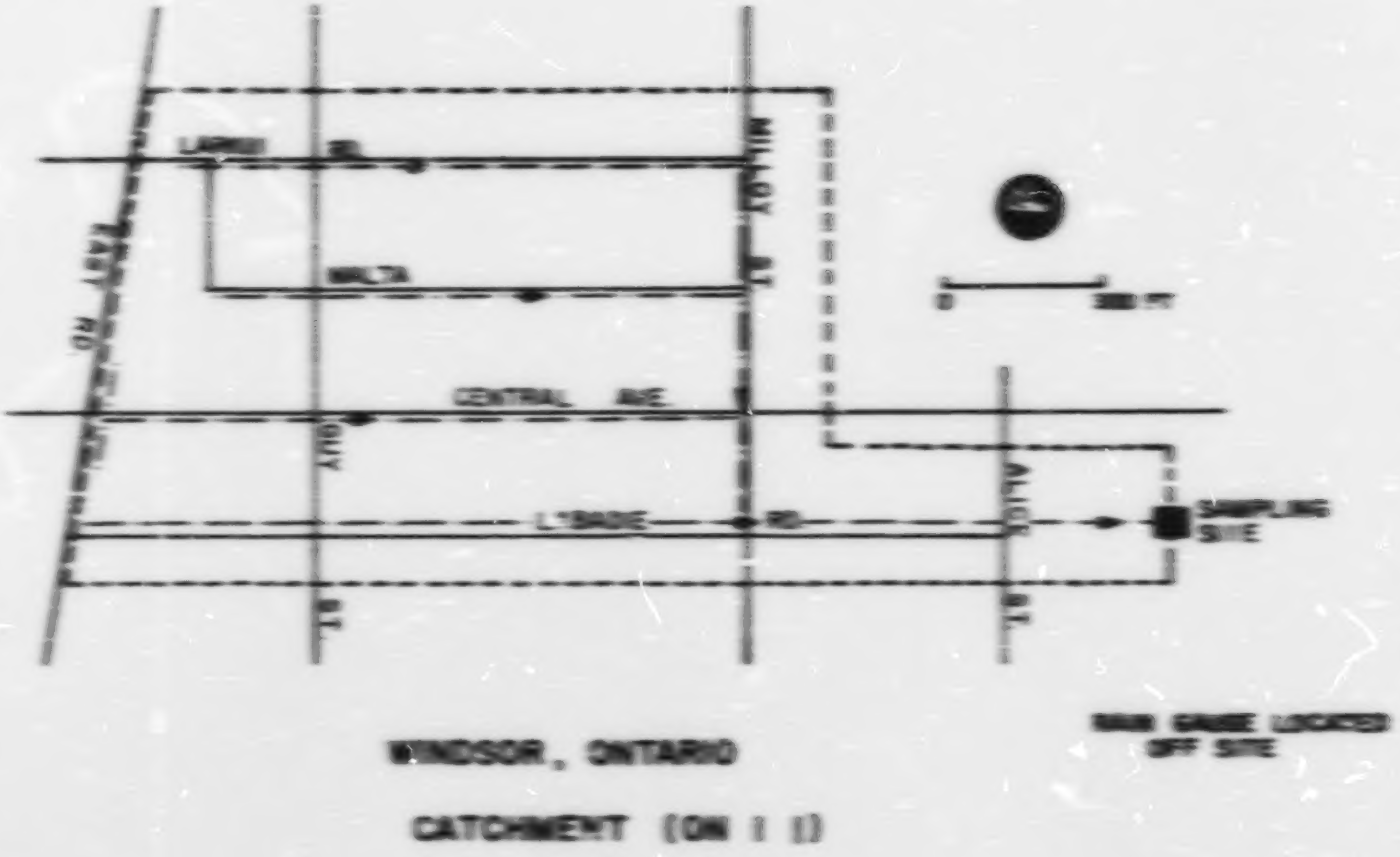
Not all parameters were sampled for all storms

Parameter	STORET Code	Units
BOD$_5$	310	mg/l
Tot. Colif.	31504	MPN/100 ml[a]
Fec. Colif.	31616	MPN/100 ml[a]
Tot. Susp. Solids (SS)	530	mg/l
Vol. SS	535	mg/l
NH_3-N	610	mg/l-N
NO_3^--N	620	mg/l-N
NO_2^--N	615	mg/l-N
oPO_4-PO_4	660	mg/l as PO_4
Cl	940	mg/l
SO_4	945	mg/l
Alkalinity	410	mg/l as $CaCO_3$
Ca. hardness	901	mg/l as $CaCO_3$
Total hardness	900	mg/l as $CaCO_3$
pH	400	
Color	80	PTU
Turbidity	70	JTU
Spec. Conductivity	95	μ mho

Some additional data were taken in composite samples during storms.

---

[a] On data tape, coliforms are given as 100 x $\log_{10}$ (MPN/100 ml).



LARIVI RD.
MALTA
MILLOY ST.
CENTRAL AVE.
GUY ST.
L'BADIE RD.
ALICE ST.
EAST RD.
SAMPLING SITE
0
300 FT
RAIN GAGE LOCATED OFF SITE
WINDSOR, ONTARIO
CATCHMENT (ON 1 1)

Figure VII-25 Windsor, Ontario, Labadie Road Catchment, 29.5 ac (11.9 ha).

SECTION VIII

DESCRIPTION OF RAINFALL-RUNOFF DATA BASE SOURCES

INTRODUCTION

The following subsections describe locations for which rainfall and runoff data have been obtained and placed in the data base. No quality data (or only unsuitable data) are available, although current studies at some sites are likely to provide such data in the future.

Again, sources included in this section were chosen primarily on the basis of quality of the data, availability and documentation. Remarks made at the introduction to Section VII apply here also. In particular, documentation varies greatly from site to site. In a few instances, the only readily available information available to UF was that contained in the RRL and ILLUDAS studies (49,50). However, in most cases, at least some other source documentation was available. The cited references should be consulted for additional information at each location.

For quantity-only locations, a table of parameter codes is not given unless there are multiple rain gages, in which case data from each gage is given a different code number (see Table VI-3). In the absence of a table, rainfall and flow values are assigned the code numbers 00050 and 00061, respectively, as indicated in Table VI-3.

Information on modeling data should again be requested directly from UF, as indicated in Section VII.

BALTIMORE, MARYLAND

Some of the earliest and most widely used urban rainfall-runoff data were gathered in Baltimore as part of the Storm Drain Research Project at The John Hopkins Unviersity. Tucker (36,40) has published data for the Northwood and Gray Haven catchments, including necessary modeling information, and the data included herein were taken from these reports. Data from other catchments, including Swansea, Montebello No. 4 and South Parking Lot No. 1, are also available (40, 50).

The Baltimore data, especially Northwood, have been extensively used for model verification, e.g., references 50, 81, 101, 112-127, 163, 174, 176-178. Such references serve as valuable supplementary material for interpretation of data.

State and City Code: MD 01

Table VIII-1. Catchments - Baltimore

No.	Name	Area ac (ha)	Sewerage	Imperviousness, %	Average Slope,%	Land Use Percentages
1	Gray Haven	23.3 (9.4)	Storm	52	0.5	Residential
2	Northwood	47.4 (19.2)	Storm	60	3	Res. 63, Com. 37

Table VIII-2. Quantity Data - Baltimore

		Flow		Rain					
				Gages Used					
No.	Catchment	Type of Flow meas.	Sampling Interval, min	No. in Catchment	No. near Catchment	Type	Sampling Interval, min	No. of Storms	Period
1	Gray Haven	f_1	1	1	-	r_1	1	28	6/63-10/66
2	Northwood	f_1	1	1	-	r_1	1	14	3/64-9/65

f_1 - Parshall flume located in open channel. Flow measurements estimated to be within ± 5%.

r_1 - Tipping bucket gage, 0.01 in. (0.25 mm) capacity.

Time synchronization: Excellent since data recorded on same chart.

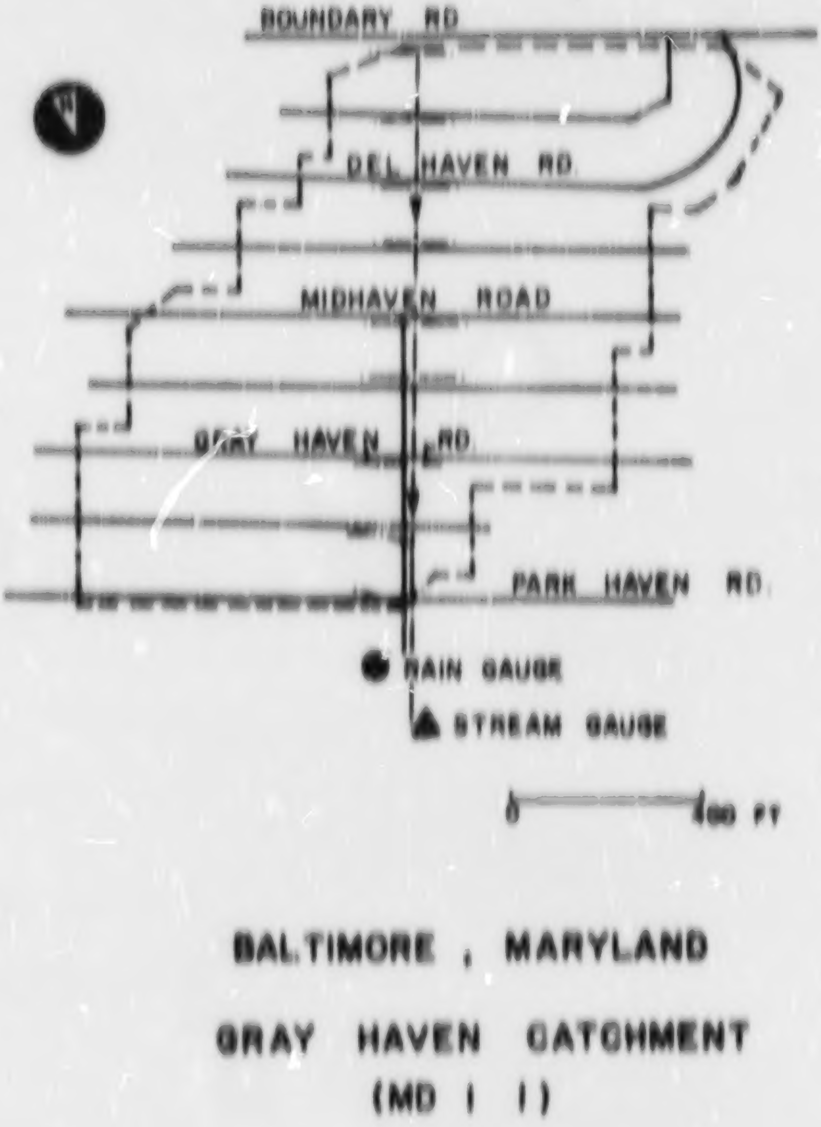

BOUNDARY RD
DEL HAVEN RD
MIDHAVEN ROAD
GRAY HAVEN RD
PARK HAVEN RD
RAIN GAUGE
STREAM GAUGE
0
400 FT
BALTIMORE, MARYLAND
GRAY HAVEN CATCHMENT
(MD I I)

Figure VIII-1 Baltimore, Maryland, Gray Haven Catchment, 23.3 ac (9.4 ha).

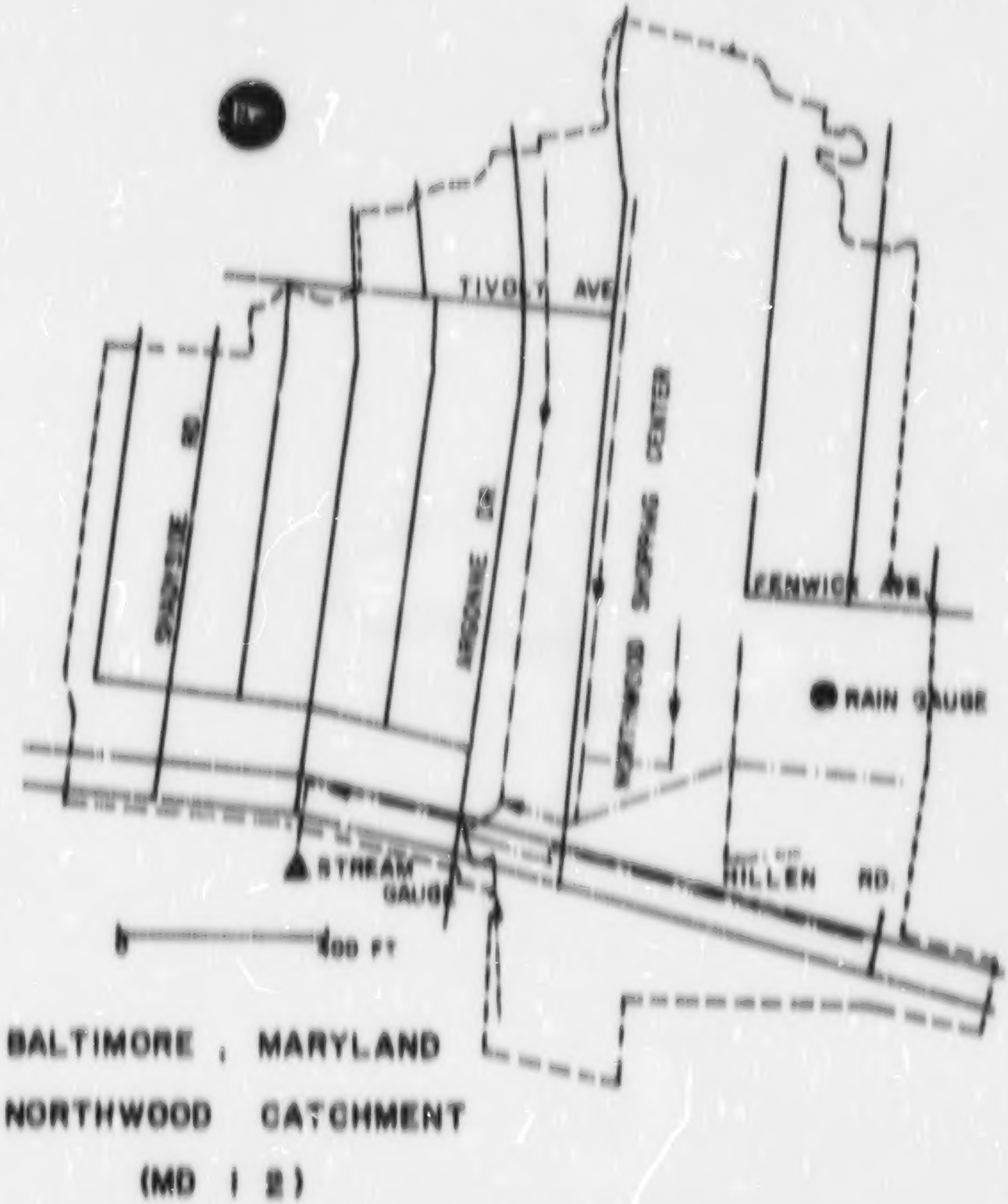

N
TIVOLY AVE
NORTHWOOD SHOPPING CENTER
FENWICK AVE
RAIN GAUGE
STREAM GAUGE
HILLEN RD
0
400 FT
BALTIMORE, MARYLAND
NORTHWOOD CATCHMENT
(MD 1 2)

Figure VIII-2 Baltimore, Maryland, Northwood Catchment, 47.4 ac (19.2 ha).

CHICAGO, ILLINOIS

During the period 1959-1963, the Chicago Department of Public Works, Bureau of Engineering, collected rainfall-runoff data for the 12.9 ac (5.2 ha) Oakdale catchment, located about 6 miles (9.6 km) northwest of downtown Chicago. These data were published by Tucker (37, 40) and have been widely used for model testing, e.g., references 1, 81, 101, 112-115, 119, 125-129,143, 174. Complete modeling data are presented by Tucker (37) to which the studies of Chow and Yen (128) and Brandstetter (1) are valuable supplements.

State and City Code: IL 01

Table VIII-3. Catchments - Chicago

No.	Name	Area ac (ha)	Sewerage	Impervious Area Directly Connected ac(ha)	 Indirectly Connected ac(ha)	Pervious Area ac(ha)	No. inlet catchbasins	Land Use
1	Oakdale	12.9 (5.2)	Combined	5.15 (2.08)	0.72 (0.29)	7.05 (2.85)	30	Dense residential

Table VIII-4. Quantity Data - Chicago

		Flow		Rain					
				Gages Used					
No.	Catchment	Type of Flow meas.	Sampling Interval, min	No. in Catchment	No. near Catchment	Type	Sampling Interval, min	No. of Storms	Period
1	Oakdale	f_1	1	-	1	r_1	1	26	5/59-9/64

f_1 - Samples 30 in. (76cm) Type "S" parabolic flume located in vault at outlet of 30 in.(76cm) combined sewer.

r_1 - Tipping bucket gage with 0.01 in. (0.25 mm) capacity located one block north of drainage area.

Time synchronization: Good. Flow and rain data were telemetered to downtown office of Dept. of Public Works. However, time of day of start of storm is not noted, so all data are relative to start of storm.

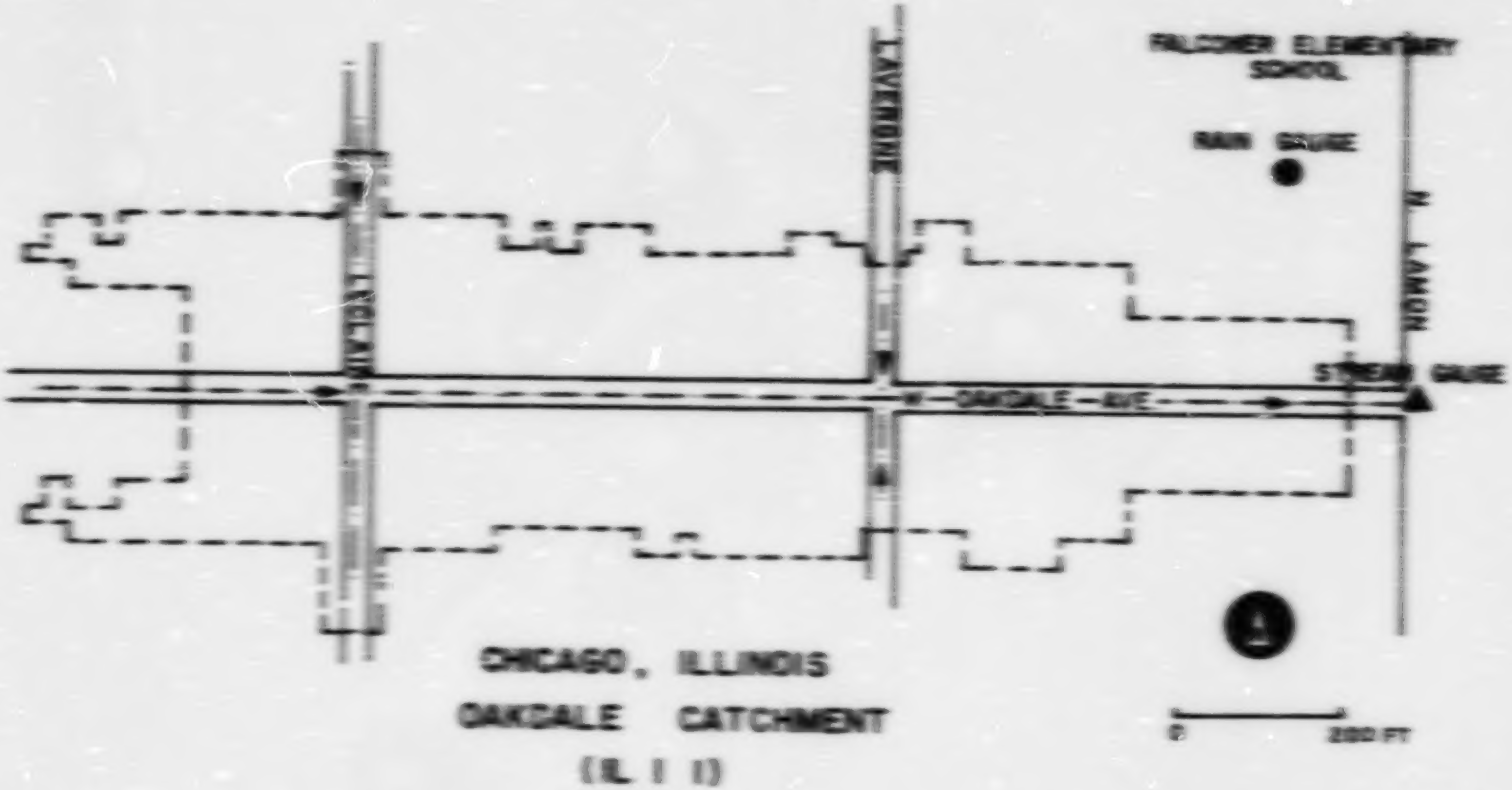

FALCONER ELEMENTARY SCHOOL
RAIN GAUGE
N. LAMON
STREAM GAUGE
OAKDALE AVE
LAVERGNE
LECLAIRE
CHICAGO, ILLINOIS
OAKDALE CATCHMENT
(IL 1 1)
0
200 FT

Figure VIII-1 Chicago, Illinois, Oakdale Catchment, 12.9 ac (5.2 ha).

CHAMPAIGN-URBANA, ILLINOIS

Runoff data for the Boneyard Creek catchment have been collected by the USGS since 1948. Rainfall data have been collected since 1949 by the Illinois State Water Survey in cooperation with the Department of Civil Engineering of the University of Illinois. Tucker (42) presents rainfall-stage data for 29 storms from October 1960 to August 1966. After having converted stages to flows via a rating curve and having keypunched the data, they were made available to UF through the courtesy of the Illinois State Water Survey.

The basin contains five recording gages. For 15 of the 28 storms included in the data base, a Thiessen weighted average of the five gages is given. For the remaining 13 storms, individual data for from three to five gages are given. Boneyard Creek data have been used by Stall and Terstriep for RRL and ILLUDAS model verification studies (50, 113) and by others (114, 115, 131, 142).

State and City Code: IL 02

Table VIII-5. Catchment - Champaign-Urbana

No.	Name	Area ac (ha)	Sewerage	Average Slope %	Imperviousness %	Impervious Area Land Use Percentage
1	Boneyard Creek	2290 (927)	Storm[a]	0.2	46.1	Streets 16.9, Alleys 0.9, Sidewalks 3.5, Commercial 7.0, Residential Rooftops 14.8, Campus 7.0.

[a] partially open channels.

Table VIII-6. Quantity Data - Champaign-Urbana

		Flow		Rain					
				Gages Used					
No.	Catchment	Type of Flow meas.	Sampling Interval, min	No. in Catchment	No. near Catchment	Type	Sampling Interval, min	No. of Storms	Period
1	Boneyard Creek	f_1	5-15	2	-	r_1	6	28	10/60-8/66

f_1 - Stage gage at concrete control. Rating curve given by Tucker (42). USGS gage ID is 3-3370.

r_1 - Weighing bucket gages with weekly charts.

Time Synchronization: Among rain gages ± 10%. Stage gage estimated to be with ± 5 min. of actual time.

Table VIII-7. Additional Rain Gage Information - Champaign-Urbana

Gage No.	Parameter Code	Thiessen Weights 5 Gages	 Gages 1,2,5[b]	 Gages 1,2,5,11[c]
1	90049	0.15	0.40	0.20
2	90048	0.20	0.30	0.20
5	90047	0.30	0.30	0.30
7	90046	0.25		
11	90045	0.10		0.30
Average	90050[a]			

[a] Used when Thiessen average rainfall of 5 gages is given (15 storms). These data were averaged because of similar rainfall patterns.

[b] Storm of 7/13/62 has rainfall for only gages 1,2,5.

[c] Storm of 6/14/64 has rainfall for only gages 1,2,5,11.

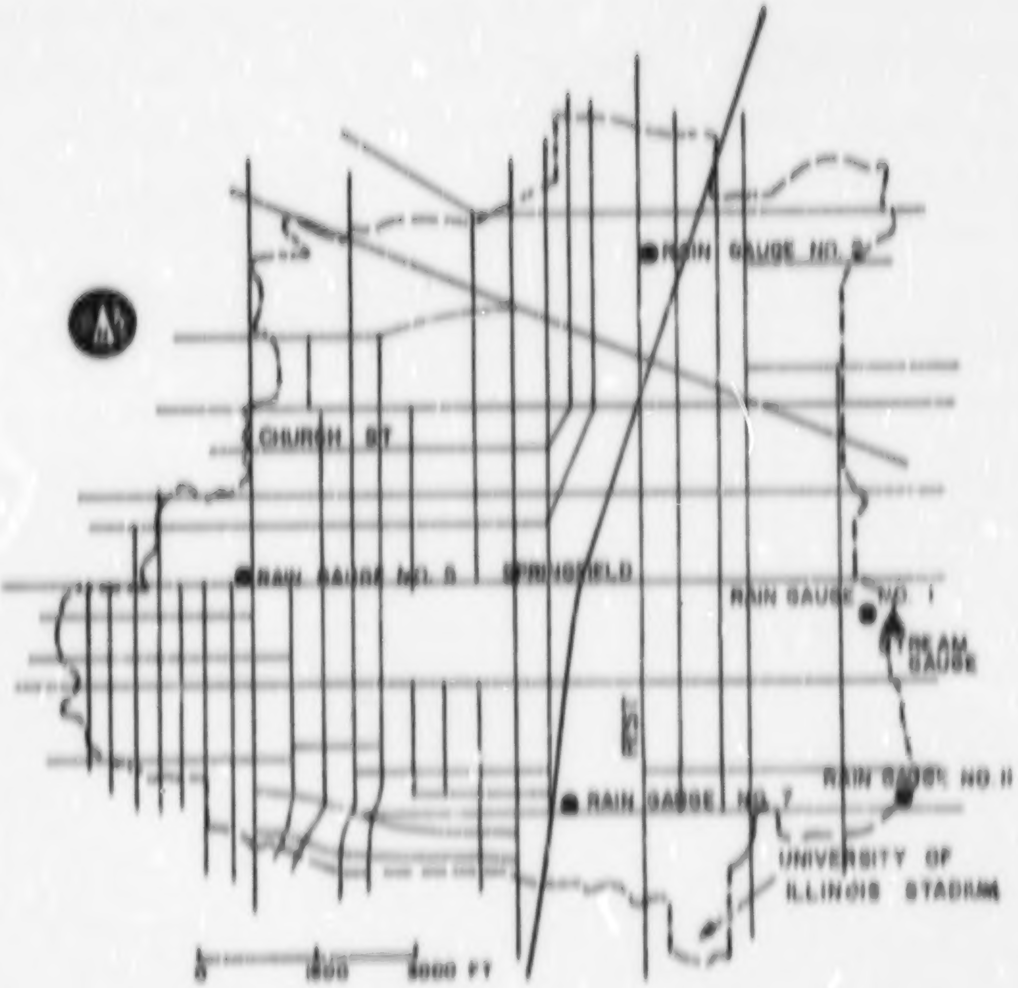

RAIN GAUGE NO. 9
CHURCH ST
RAIN GAUGE NO. 5
SPRINGFIELD
RAIN GAUGE NO. 1
STREAM GAUGE
RAIN GAUGE NO. 7
RAIN GAUGE NO. 11
UNIVERSITY OF ILLINOIS STADIUM
0
1000
2000 FT
CHAMPAIGN - URBANA , ILLINOIS
BONEYARD CREEK CATCHMENT (IL 2 1)

Figure VIII-4 Champaign-Urbana, Illinois, Boneyard Creek Catchment, 2290 ac. (927 ha).

BUCYRUS, OHIO

During 1969, Burgess and Niple, Ltd. conducted combined sewer overflow studies in Bucyrus (132). Their report contains considerable information about the three sewer districts sampled, including limited quality data. Data for Sewer District No. 8 were keypunched and supplied to UF through the courtesy of the Illinois State Water Survey.

The data were used in testing the RRL and ILLUDAS models (49, 50). Terstriep and Stall (50) suggest sampling errors at high flows, i.e., high values of measured flows may be lower than their true values. In addition, the flat terrain and indeterminate drainage pattern create ponding during some storms.

State and City Code: OH 01

Table VIII-E. Catchment - Bucyrus

No.	Name	Area ac (ha)	Sewerage	Population	Average Slope, %	Imperviousness, %	Land Use Percentages
1	Sewer Dist. No.8	179 (72.5)	Combined	2020	0.85	33.7	Res. 59.6, Com. 6.3, Ind. 7.8, institutional 4.6, undev. 12.9, railroad 0.2, streets 8.6

Table VIII-F. Quantity Data - Bucyrus

		Flow		Rain					
				Gages Used					
No.	Catchment	Type of Flow meas.	Sampling Interval, min	No. in Catchment	No. near Catchment	Type	Sampling Interval, min	No. of Storms	Period
1	Sewer District No. 8	f_1	5-15	1	-	r_1	10	10	3/69-9/69

f_1 - Stage measurements by Stevens Type-F recorder located behind 8 ft. (2.4m) rectangular weir. Readings could be made to nearest 0.01 ft. (3mm).

r_1 - Bendix weighing-bucket gage with 24 hour chart.

Time synchronization: Rain and stage gage times estimated to be within ± 2 min.

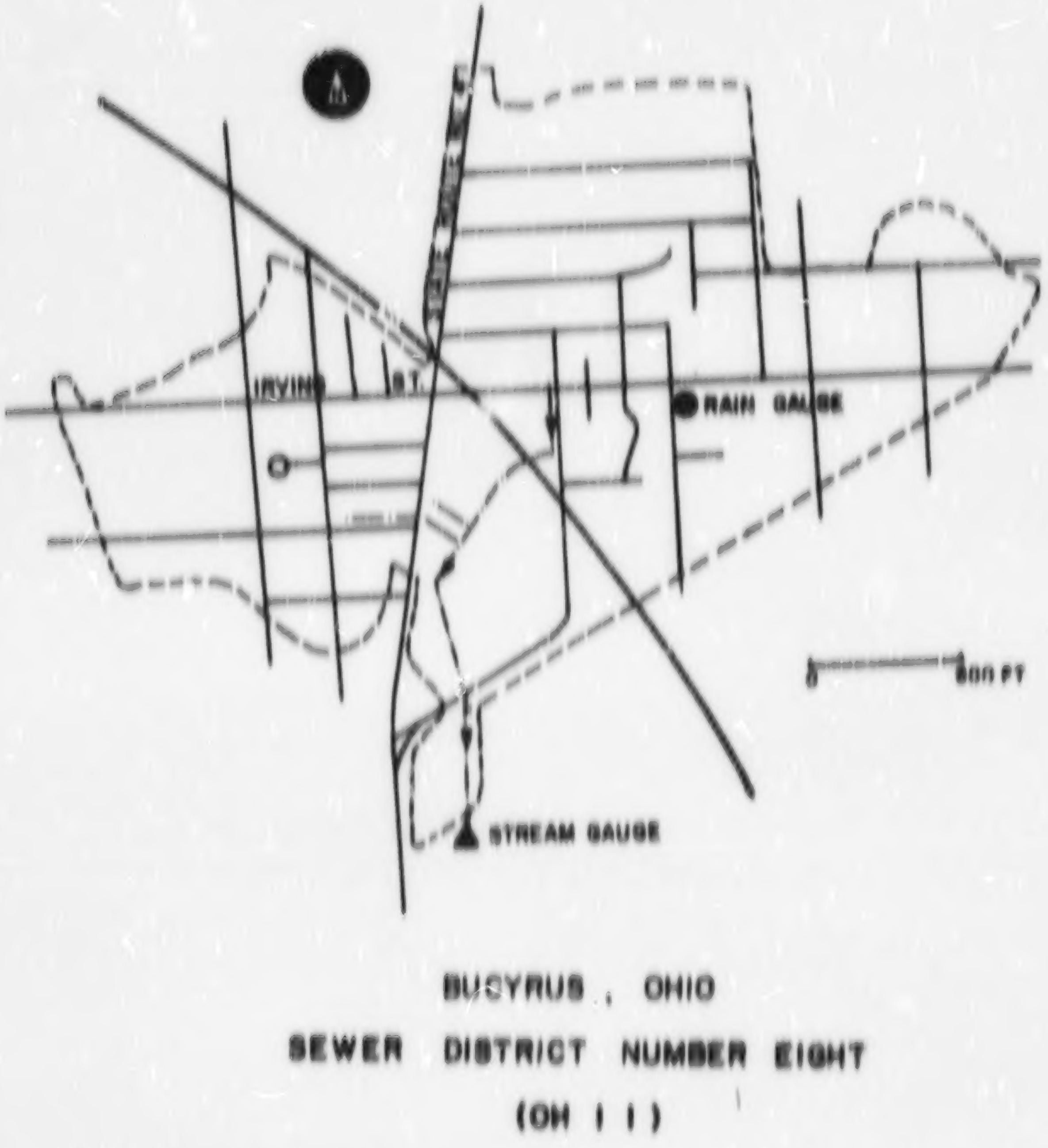

IRVING ST.
RAIN GAUGE
0
800 FT
STREAM GAUGE
BUCYRUS, OHIO
SEWER DISTRICT NUMBER EIGHT
(OH 11)

Figure VIII-5 Bucyrus, Ohio, Sewer District Number Eight, 179 ac (72.5ha).

FALLS CHURCH, VIRGINIA

The USGS began recording rainfall-runoff data in the residential Tripps Run Basin near Washington, D.C. in 1959. Tucker (42) reports on its characteristics and sampling program. The Illinois State Water Survey reduced original stage and rainfall records for a 326 ac (130 ha) tributary. The keypunched data were received by UF through their courtesy. A disadvantage in the data is the 0.1 in. (2.5 mm) capacity of the tipping bucket rain gage utilized. In testing the RRL and ILLUDAS models, Stall and Terstriep (49, 50) report some difficulty in obtaining good modeling information. The data have also been used in studies of the effect of urbanization on hydrographs (176, 177).

State and City Code: VA 01

Table VIII-10. Catchment - Falls Church

No.	Name	Area ac (ha)	Sewerage	Total Paved Area, %	Channel Length, mi (km)	Channel Slope	Land Use
1	Tripps Run Tributary	322 (130)	Storm	31	1.1 (1.76)	0.0193	Residential with some commercial

Table VIII-11. Quantity Data - Falls Church

No.	Catchment	Flow		Rain					Period
		Type of Flow meas.	Sampling Interval, min	Gages Used: No. in Catchment	Gages Used: No. near Catchment	Type	Sampling Interval, min	No. of Storms	
1	Tripps Run Tributary	f_1	5-15	1	-	r_1	10	10	3/63-10/67

f_1 - Stage measurements by a Stevens graphical recorder on a rated culvert. USGS Gage No. 1-6526.45

r_1 - Tipping bucket gage with 0.1 in. (2.5 mm) capacity.

Time synchronization: Good since rainfall and stage data recorded on same chart.

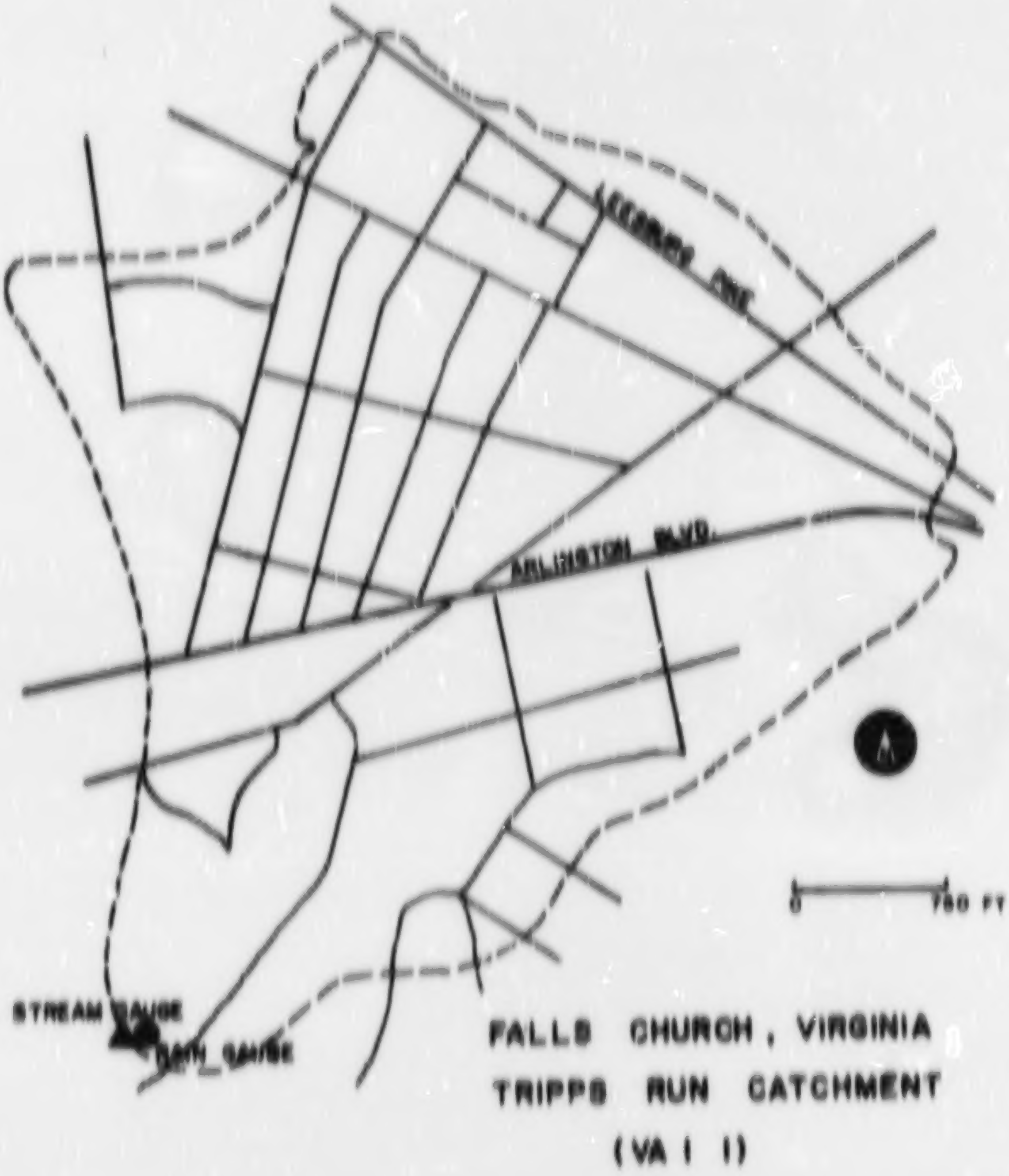

LEESBURG PIKE
ARLINGTON BLVD.
0
750 FT
STREAM GAUGE
RAIN GAUGE
FALLS CHURCH, VIRGINIA
TRIPPS RUN CATCHMENT
(VA I 1)

Figure VII-6 Falls Church, Virginia, Tripps Run Catchment, 322 ac (130 ha).

WINSTON-SALEM, NORTH CAROLINA

The USGS gages the 384 ac (155 ha) Tar Branch basin at Walnut Street in Winston-Salem. Keypunched rainfall-runoff data were made available to UF through the courtesy of the Illinois State Water Survey who utilized them in testing the RRL and ILLUDAS models (49, 50). The data have also been used for hydrograph analyses (171, 176). Tucker (42) provides additional information on the basin and gaging installations.

State and City Code: NC 01

Table VIII-12. Catchment - Winston-Salem

No.	Name	Area ac (ha)	Sewerage	Total Paved Area, %	Channel Length, mi (km)	Channel Slope	Land Use
1	Tar Branch	384 (155)	Storm	39	1.27 (2.03)	0.0275	Residential and business

Table VIII-13. Quantity Data - Winston-Salem

		Flow		Rain					
				Gages Used					
No.	Catchment	Type of Flow meas.	Sampling Interval, min	No. in Catchment	No. near Catchment	Type	Sampling Interval, min	No. of Storms	Period
1	Tar Branch	f_1	5	1	-	r_1	5	17	6/69-12/69

f_1 - Continuous stage record above a rated culvert. Fischer-Porter automatic data recorder. USGS Station no. 20115863.

r_1 - Float-type gage with punched output onto paper tape.

Time synchronization: Good since both rain and stage gage use same clock.

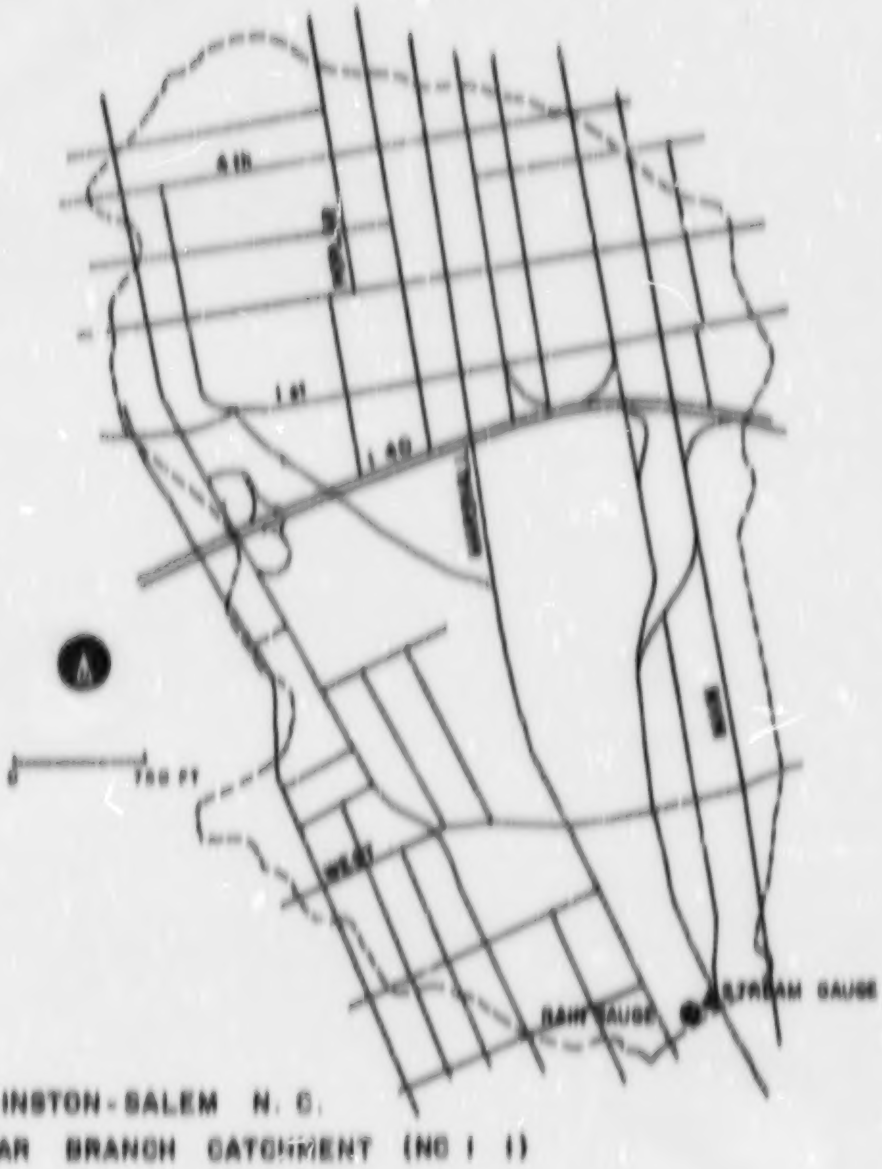

4th
1 st
I 40
0
700 FT
RAIN GAUGE
STREAM GAUGE
WINSTON-SALEM N. C.
TAR BRANCH CATCHMENT (NC I 1)

Figure VIII-7 Winston-Salem, N.C., Tar Branch Catchment, 384 ac (155 ha).

JACKSON, MISSISSIPPI

USGS data have been collected since 1965 on the residential Crane Creek basin in Jackson and utilized by the Illinois State Water Survey for RRL and ILLUDAS model verification (49, 50). Keypunched data were obtained by UF through the courtesy of the Survey. The data have also been used for unit hydrograph analyses (171) and model comparisons (172). Other information on urban runoff in Jackson is available in a USGS report by Wilson (136).

State and City Code: MS 01

Table VIII-14. Catchment - Jackson

No.	Name	Area ac (ha)	Sewerage	Total Paved Area, %	Channel Length, mi (km)	Channel Slope	Land Use
1	Crane Creek	285 (115)	Storm	24	0.8 (1.3)	0.0067	Residential

Table VIII-15. Quantity Data - Jackson

		Flow		Rain					
				Gages Used					
No.	Catchment	Type of Flow meas.	Sampling Interval, min	No. in Catchment	No. near Catchment	Type	Sampling Interval, min	No. of Storms	Period
1	Crane Creek	f_1	5	1	-	r_1	5	16	5/65-5/66

f_1 - Continuous sta[illegible] record at a rated box culvert (Meadowbrook Dr.). Digital output on punched tape. USGS St[illegible] no. 4857.80.

r_1 - Float-type gage with punched output onto paper tape, using same clock as stage gage.

Time synchronization: Good since both rain and stage gage use same clock.

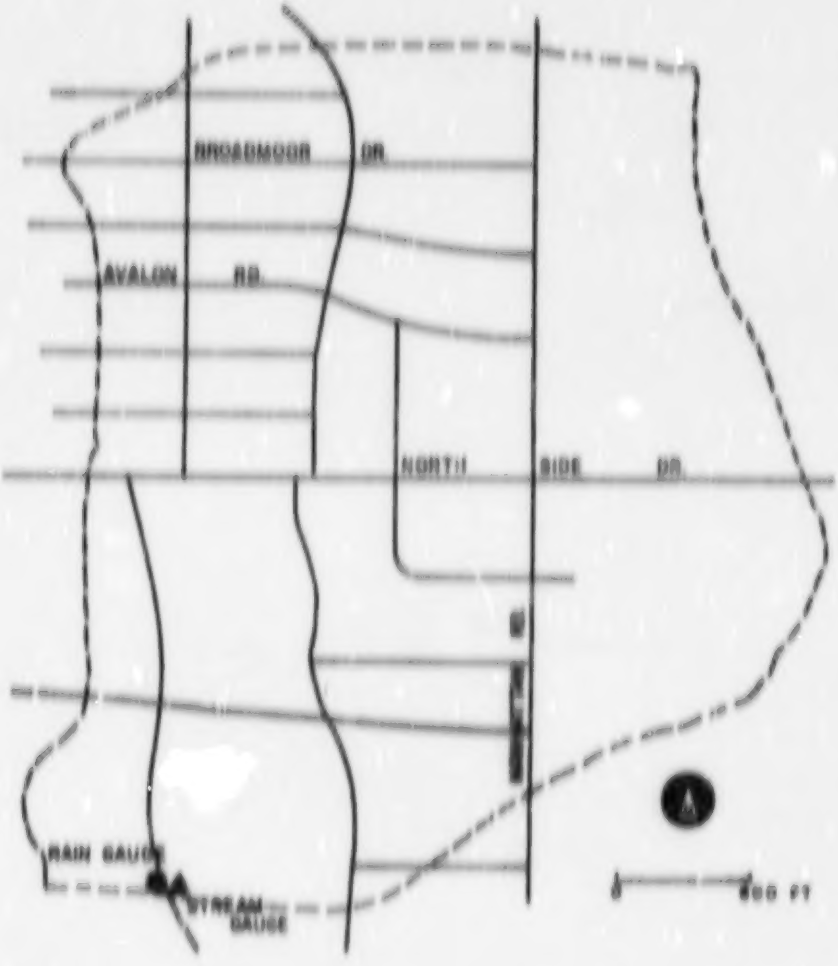

BROADMOOR DR.
AVALON RD.
NORTH SIDE DR.
RAIN GAUGE
STREAM GAUGE
0
JACKSON , MISSISSIPPI
CRANE CREEK CATCHMENT
(MS I I)

Figure VIII-8 Jackson, Mississippi, Crane Creek Catchment, 285 ac (115 ha).

WICHITA, KANSAS

USGS data have been collected on the residential Dry Creek basin in Wichita and utilized by the Illinois State Water Survey for RRL and ILLUDAS model verification (49, 50). Keypunched data were obtained by UF through the courtesy of the Survey. The data have also been used for studies of hydrologic effects of urbanization in the area (179).

State and City Code: KS 01

Table VIII-16. Catchment - Wichita

No.	Name	Area ac (ha)	Sewerage	Total paved Area, %	Land Use
1	Dry Creek	1883 (762)	Storm (open channel)	31	Residential with commercial strips

Table VIII-17. Quantity Data - Wichita

		Flow		Rain					
				Gages Used					
No.	Catchment	Type of flow meas.	Sampling Interval, min	No. in Catchment	No. near Catchment	Type	Sampling Interval, min	No. of Storms	Period
1	Dry Creek	f_1	5	1	-	r_1	5	8	5/64-7/65

f_1 - Continuous stage record at a rated bridge (Lincoln St.). Digital output on punched tape. USGS Gage No. 7144330.

r_1 - Float-type gage with punched output onto paper tape, using same clock as stage gage.

Time synchronization: Good since both rain and stage gage use same clock.

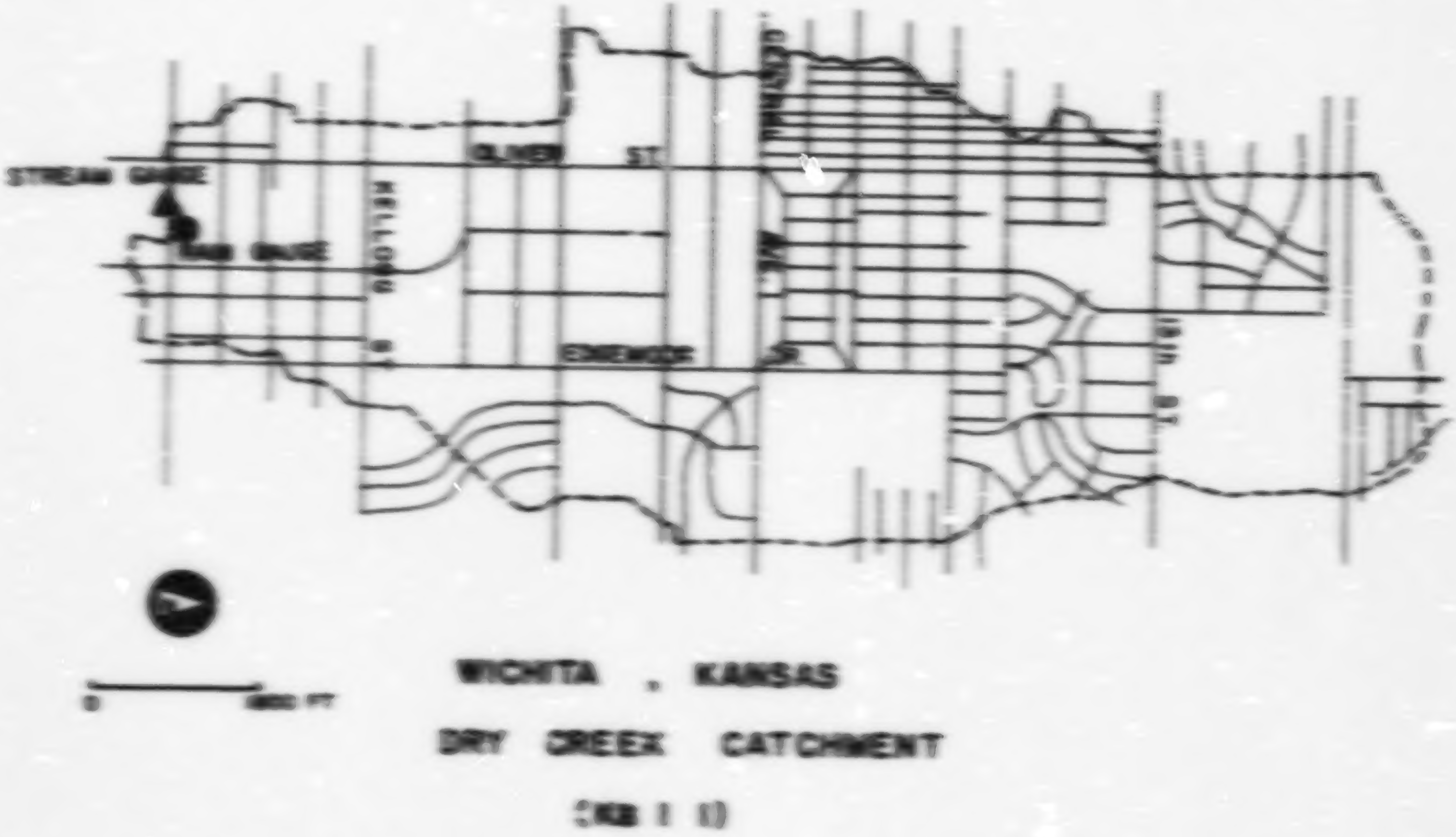

STREAM GAGE
RAIN GAGE
KELLOGG ST.
OLIVER ST.
EDGEMOOR ST.
CENTRAL AVE.
13TH ST.
0
FT
WICHITA , KANSAS
DRY CREEK CATCHMENT
(KS 1 1)

Figure VIII-9 Wichita, Kansas, Dry Creek Catchment, 1883 ac (762 ha).

WESTBURY, LONG ISLAND, NEW YORK

In connection with a larger hydrologic study in Nassau County, New York, the USGS monitored inflow from the 14.7 ac (6.0 ha) residential Woodoak Drive basin into a small recharge basin. Seaburn reports the details of the 1966-67 study (137) with further information on the flow measurement techniques (138) and related hydrology efforts in the area (139). Thus, other parameters related to the recharge basin were measured as well. The Illinois State Water Survey utilized the data for verification of the RRL and ILLUDAS models (49, 90). Keypunched data were obtained through the courtesy of the Survey.

State and City Code: NY 01

Table VIII-28. Catchment—Westbury, L.I.

No.	Name	Area ac (ha)	Sewerage	Area of Streets, %	Total^a Imperviousness	No. Houses	Land Use
1	[illegible]	14.7 (6.0)	Storm	12	33	52	Residential

[a] Includes streets, driveways, sidewalks and roofs.

Table VIII-29. Quantity Data—Westbury, L.I.

		Flow		Rain					
				Gages Used					
No.	Catchment	Type of Flow meas.	Sampling Interval, min	No. in Catchment	No. near Catchment	Type	Sampling Interval, min	No. of Storms	Period
1	[illegible]	c_1	5	-	1	r_1	15	18	9/66-5/68

c_1 - Continuous stage record at a V-notch weir in 24 in. (61cm) concrete outlet pipe (only pipe in basin). Digital output on punched tape.

r_1 - Weighing bucket gage located about 900 ft. (274 m) southeast of basin.

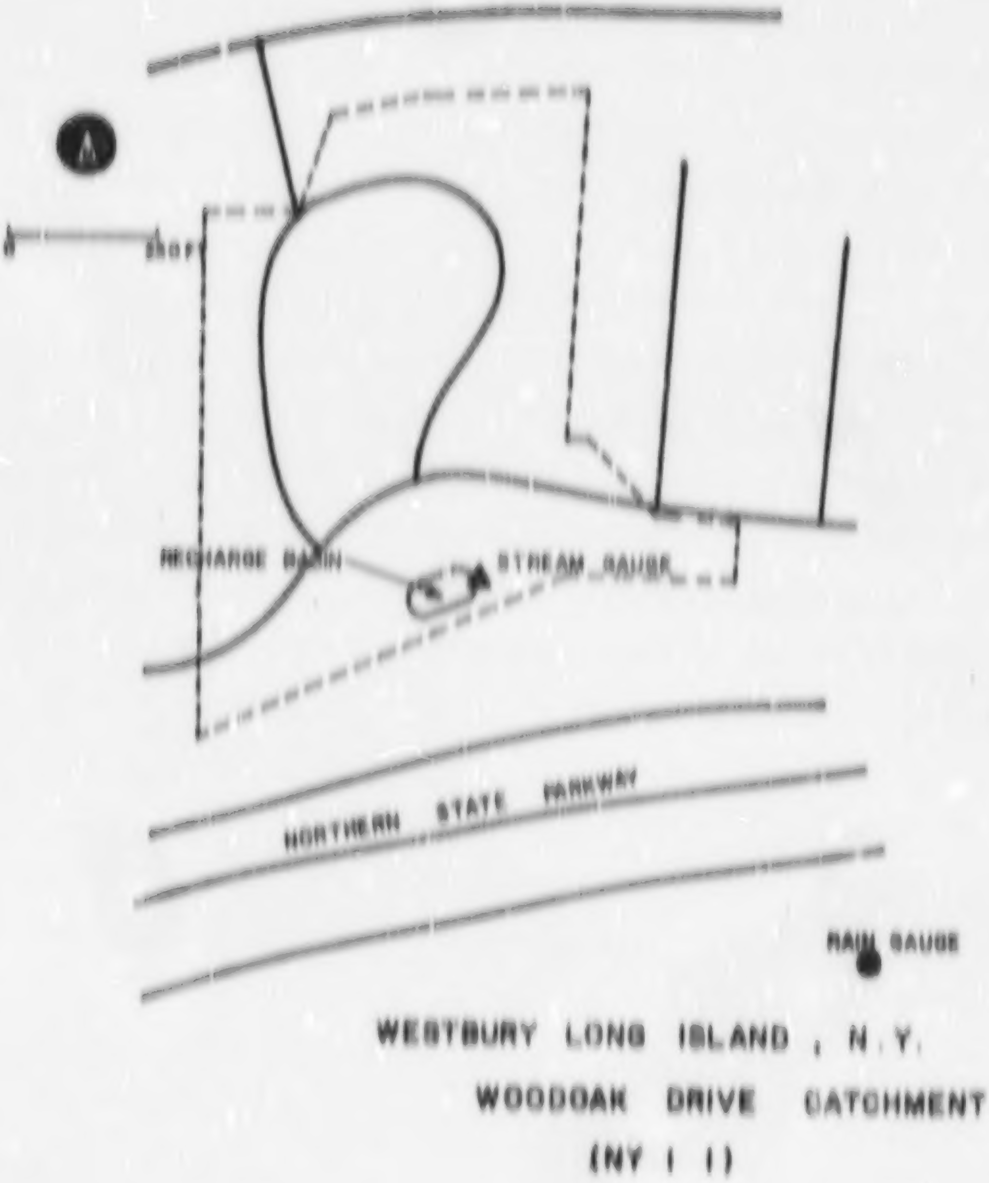

0
300'
RECHARGE BASIN
STREAM GAUGE
NORTHERN STATE PARKWAY
RAIN GAUGE
WESTBURY LONG ISLAND, N.Y.
WOODOAK DRIVE CATCHMENT
(NY I 1)

Figure VIII-10 Westbury, Long Island, New York, Woodoak Drive Catchment, 14.7 ac (6.0 ha).

PHILADELPHIA, PENNSYLVANIA

The 5326 ac (2156 ha) Wingohocking basin is Philadelphia's largest combined sewer catchment. Tucker (40) describes in detail the gaging program at Wingohocking which was initiated by the U.S. Public Health Service in 1963 and has been under the direction of the Philadelphia Water Department since 1965. Guarino, Radziul and Greene (140) discuss Wingohocking in the context of overall combined sewer problems in Philadelphia. Tucker (41) also provides additional information on the city's gaging program, plus more detailed information on the raingage network within the city (38). There are four raingages which service the Wingohocking area. Keypunched rainfall-runoff data were obtained through the courtesy of the Illinois State Water Survey who used them for RRL and ILLUDAS verification (49, 50). They indicate a possible change during 1966 in the rating curve used for flow calculations. The data have also been used for SWMM verification (102) in which some of the composited quality samples are utilized. These composited quality data are not included in the data base. SWMM input data are also given in reference 102. Additional SWMM simulations of several of the storms included in this data base have been performed by Hagarman and Dressler (141).

State and City Code: PA 02

Table VIII-20. Catchment - Philadelphia

No.	Name	Area ac (ha)	Sewerage	1960 Population	Impervious-ness %	Length of Sewers, miles (km)	Land Use Percentages
1	Wingohocking	5362[a] (2171)	Combined	373,085	75	45 (72)	Single Family Res. 86.2, Multi-Family Res. 5.0, Open 6.8

[a] Reference 48. Reference 102 gives 5432 ac (2199 ha) and references 49 and 50 give 5326 ac (2156 ha).

Table VIII-21. Quantity Data - Philadelphia

		Flow		Rain					
				Gages Used					
No.	Catchment	Type of Flow meas.	Sampling Interval, min	No. in Catchment	No. near Catchment	Type	Sampling Interval, min	No. of Storms	Period
1	Wingohocking	f_1	15	2	3	r_1	5	22	7/67-8/68

f_1 - Depth measurements 450 ft (137 m) upstream from calibrated (physical model) broad-crested weir, which is 87 ft (27 m) upstream from 21 by 24 ft (6.4 by 7.3 m) horseshoe-shaped combined sewer outfall. Continuous depth record on strip chart from [illegible] depth recorder. Note: Given flows are overflows over weir. See Table VIII-23 for estimate of diversion into interceptor upstream of weir. Dry weather flow estimated to be about 30 cfs (0.86 m^3/sec).

r_1 - Weighing type with minimum scale divisions of 5 min. See Table VIII-22 for further information.

Time Synchronization: Rain gage network estimated to be within ± 5 min of clock time. Variation in 1 in/hr (2.5 cm/hr) speed of depth gage strip chart may lead to variations with clock time greater than 5 min.

Table VIII-22. Additional Rain Gage Information - Philadelphia
See also reference 38.

Gage No.	City Gage No.	Name	Parameter Code	Approximate Elev. ft (m)		Thiessen Weight
1	18	Roosevelt	90050	300	(91)	0.58
2	8	Heins	90049	140	(43)	0.12
3	17	Queen Lane	90048	220	(67)	0.15
4	7	Harrow Gate	90047	80	(24)	0.15
5	20	Shawmont[a]	90046			

[a] Located to west of catchment. Data also included in data base.

Table VIII-23. Estimated Interceptor Diversions - Philadelphia

The maximum capacity of the 102 in.(259 cm) interceptor is 270 cfs (7.6 m^3/sec). It also may receive up to 150 cfs (4.3 m^3/sec) from an upstream 60 in.(152 cm) pipe. Actual diversion through interceptor will depend upon storm pattern. However, in reference 102, the following estimates are given.

Total Flow (Diversion plus Overflow) cfs	(m^3/sec)	Estimated Diversion cfs	(m^3/sec)
0 - 500	(0 - 14.2)	Up to 200	(5.7)
500 - 1000	(14.2 - 28.3)	150	(4.3)
1000 - 1500	(28.3 - 42.5)	100	(2.8)
1500	(42.5)	50	(1.4)

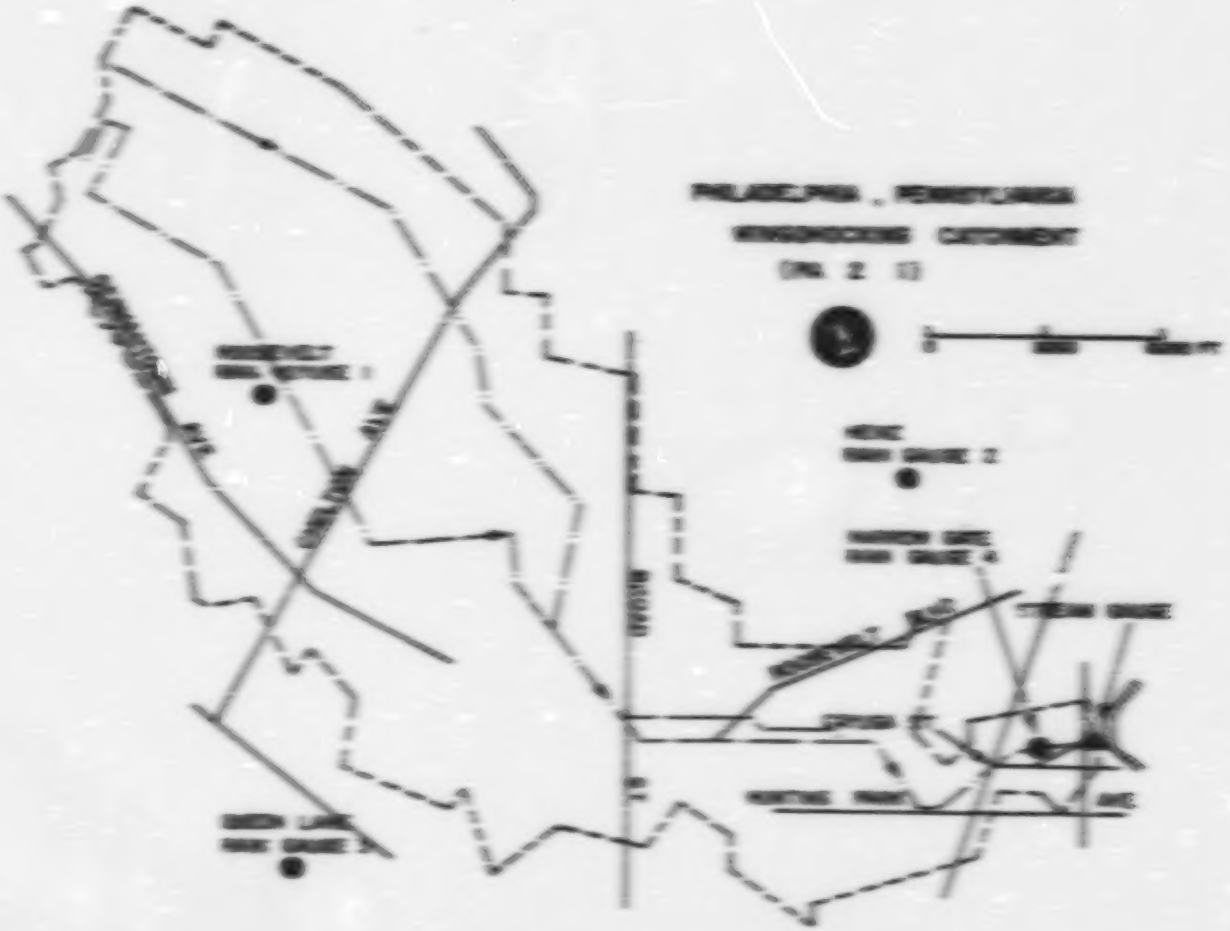

PHILADELPHIA, PENNSYLVANIA
WINGOHOCKING CATCHMENT
(PA. 2 1)
0
RAIN GAUGE 1
RAIN GAUGE 2
RAIN GAUGE 3
RAIN GAUGE 4
STREAM GAUGE
BROAD
ST.
AVE.

Figure VIII-11 Philadelphia, Pennsylvania, Wingohocking Catchment, 5362 ac (2171 ha).

LOS ANGELES, CALIFORNIA

The 252 ac (102 ha) Echo Park basin is a steep, residential catchment in north central Los Angeles. Copies of strip chart records of rainfall and runoff from 1954 to 1974, plus considerable catchment and other information, were received by UF directly from the City of Los Angeles, Department of Public Works, Bureau of Engineering. For purposes of the data base, reduced keypunched data were also obtained through the courtesy of the Illinois State Water Survey who used them for RRL and ILLUDAS model verification (49, 50). The HSP model has also been applied to this basin (142) during which it was estimated that measured flows could be in error by more than 20 percent due to uncertainty in the roughness and the supercritical flow velocities in the sewer. Terstriep and Stall (50) also point out that for a basin this steep, rainfall resolution at intervals less than 4 minutes would be desirable, but the 24-hour rain gage charts do not permit it.

State and City Code: CA 02

Table VIII-24. Catchment - Los Angeles

No.	Name	Area ac (ha)	Sewerage	Imperviousness, % 1956	Imperviousness, % 1970	1973 Population	Land Use
1	Echo Park	252 (102)	Storm	40.5	53.8	2850[a]	Residential with some commercial

[a] Estimate using population density of Larger Echo Park District of Los Angeles.

Table VIII-25. Quantity Data - Los Angeles

		Flow		Rain					
			Sampling	Gages Used			Sampling		
No.	Catchment	Type of Flow meas.	Interval, min	No. in Catchment	No. near Catchment	Type	Interval, min	No. of Storms	Period
1	Echo Park	f_1	2 - 10	1	-	r_1	4	19	2/58-12/70

f_1 - Rating curve from Manning equation (n=0.013, slope = 0.008) in 51 in. (130 cm) concrete arch storm sewer. Stage records on Stevens Type A recorder with 24 hr chart.

r_1 - Weighing bucket gage with 24 hr chart.

Time Synchronization: Possible errors due to separate clocks on rain and stage gages.

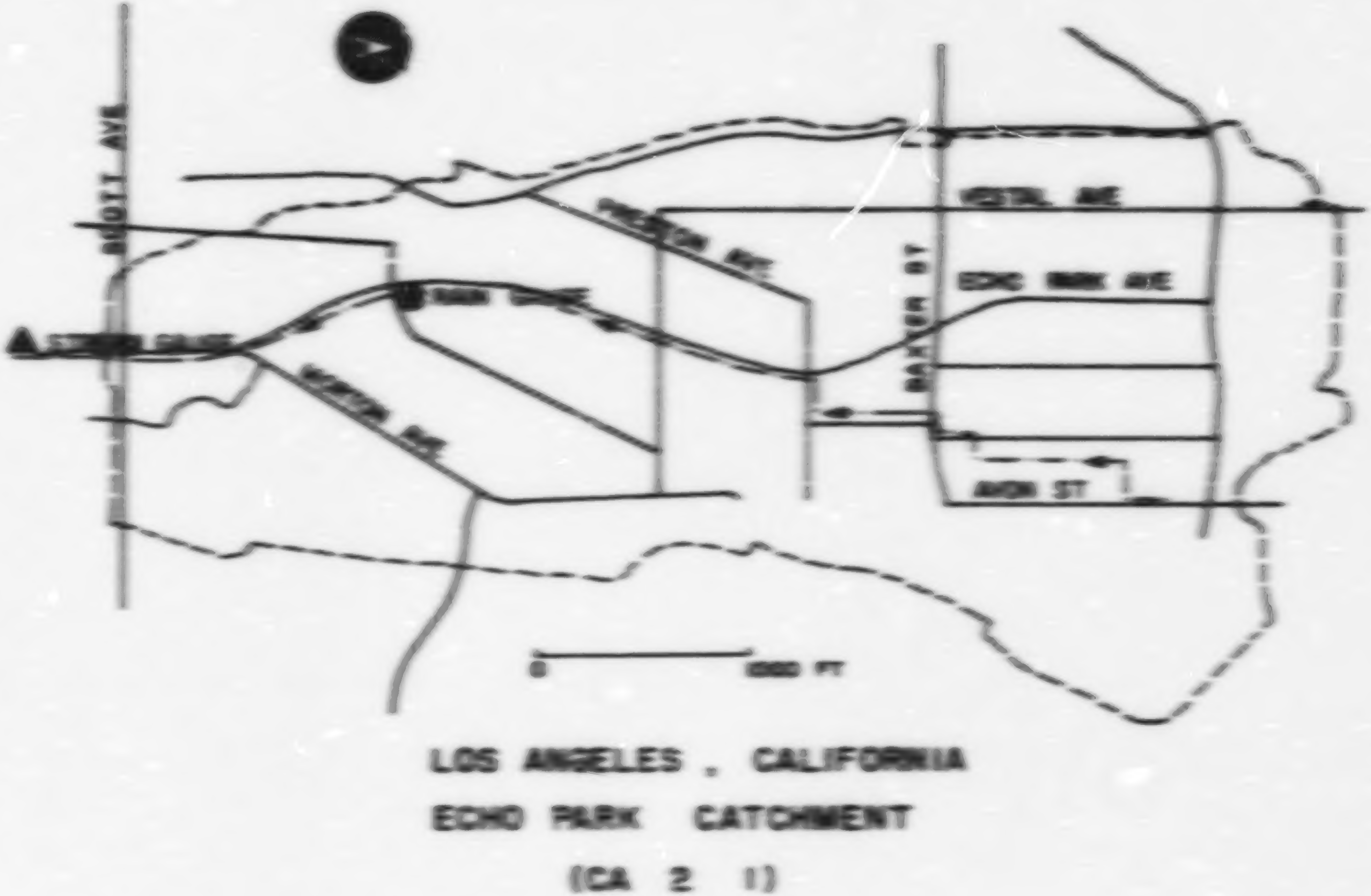

SCOTT AVE
STREAM GAUGE
RAIN GAUGE
PRESTON AVE
BENTON AVE
BAXTER ST
VESTAL AVE
ECHO PARK AVE
AVON ST
0
1000 FT
LOS ANGELES , CALIFORNIA
ECHO PARK CATCHMENT
(CA 2 1)

Figure VIII-12 Los Angeles, California, Echo Park Catchment, 252 ac (102 ha).

PORTLAND, OREGON

The City of Portland, Department of Public Works has collected rainfall-runoff data at the 75 ac (30 ha) residential Eastmoreland catchment since early 1975. More recently, 24 rain gages and 14 sewer monitors have been installed around the city, which are sampled at 15 second intervals and output stored on magnetic tapes. In addition, EPA Section 208 quality sampling programs have been initiated on the Eastmoreland catchment and four others. Data from these may be included in the data base at a future date.

Eastmoreland rainfall-runoff data have been used to calibrate an urban runoff model developed for the City of Portland (163). Additional information on the catchment is included therein.

State and City Code: OR 01

Table VIII-26. Catchment - Portland

No.	Name	Area ac (ha)	Sewerage	Average Slope	Population Density, persons/ac (persons/ha)	Land Use
1	Eastmoreland	75 (30)	Combined	0.06	18.2 (45)	Single family res.

Table VIII-27. Quantity Data - Portland

		Flow		Rain					
				Gages Used					
No.	Catchment	Type of flow meas.	Sampling Interval, min	No. in Catchment	No. near Catchment	Type	Sampling Interval, min	No. of Storms	Period
1	Eastmoreland	f_1	0.25	0	1	r_1	0.25	24	3/75-8/75

f_1 - Brooks magnetic flow meter in 21 in. (53cm) C.S.P. (slope 0.10). Values logged on Metro data 616 Data Logger at 15 sec intervals whenever flow is greater than 1.0 cfs (0.028 m^3/sec). See Table VIII-28 for dry weather flow and infiltration information.

r_1 - Weather Measure No. P-501 tipping bucket rain gage with 0.01 in. (0.25 mm) bucket capacity. Interrogated for number of tips every 15 seconds. Data base tape stores time and cumulative total (tube number 90060) to avoid computing intensities over odd time intervals.

Time synchronization, rainfall-flow: Excellent since both records are recorded using same clock.

Table VIII-28. Dry Weather Flow and Infiltration Information - Portland

Average daily DWF for the Eastmoreland area has been measured at approximately 0.1 cfs (0.003 m^3/sec). This corresponds roughly to 50 gal/day per capita (0.19 m^3/day per capita). Infiltration into the system is minimal and of the same order of magnitude as the average DWF. Hourly correction factors for DWF (excluding infiltration) have been determined and are given below.

Hour	Correction Factor[a]
0	1.0
1	0.6
2	0.3
3	0.2
4	0.1
5	0.1
6	0.1
7	0.6
8	0.5
9	0.6
10	0.4
11	0.4
12	1.3
13	1.1
14	1.0
15	0.95
16	0.95
17	1.1
18	1.2
19	1.4
20	1.7
21	1.6
22	1.5
23	1.3
	24.0

---

[a] Multiply by average DWF to get value at each hour. These values have been adjusted slightly from data supplied by city so that they sum to 24.0.

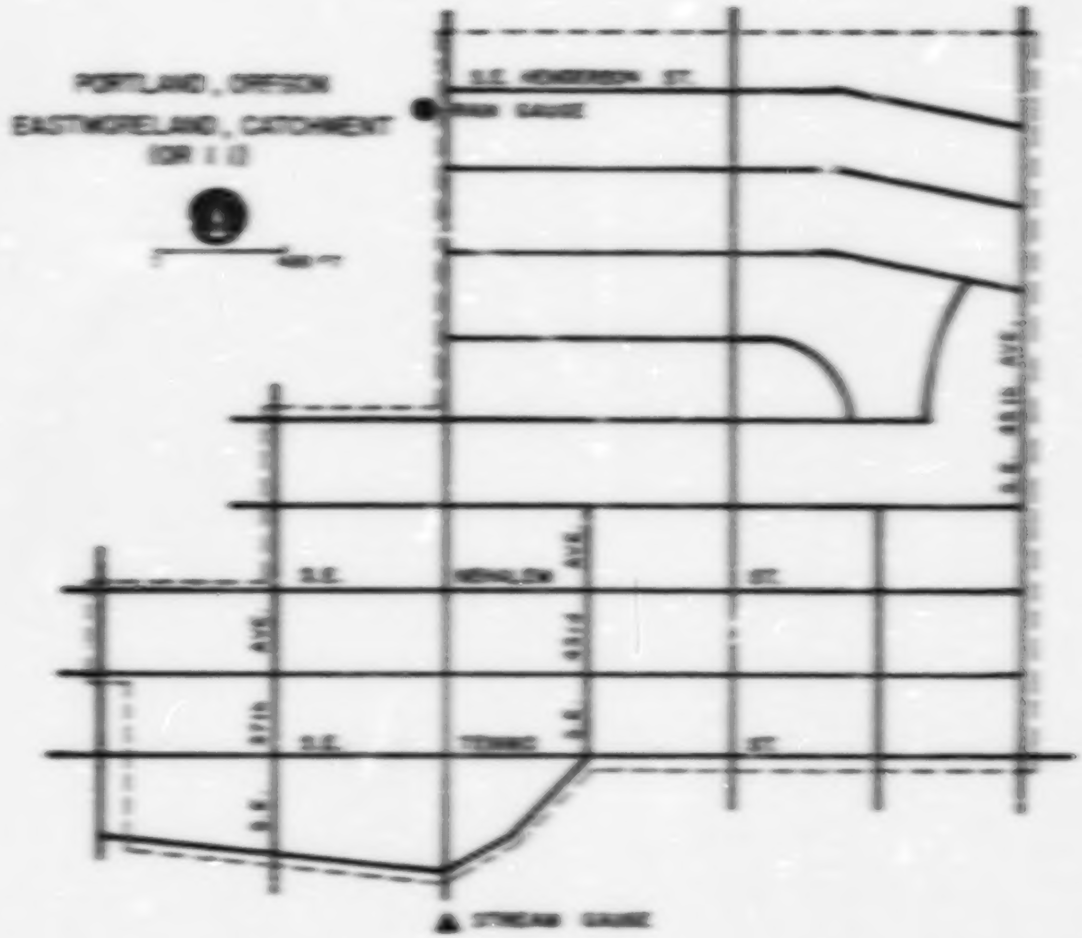

PORTLAND, OREGON
EASTMORELAND, CATCHMENT
(OR 1 1)
S.E. HENDERSON ST.
RAIN GAUGE
S.E. 46th AVE.
S.E. MALDEN ST.
S.E. TENINO ST.
S.E. 47th AVE.
S.E. 48th AVE.
STREAM GAUGE

Figure VIII-13 Portland, Oregon, Eastmoreland Catchment, 75 ac (30 ha).

HOUSTON, TEXAS

In cooperation with the City of Houston, the USGS initiated collection of urban rainfall-runoff data at more than 20 sites in 1964. Annual reports have been published (e.g., 164, 165) containing catchment information and detailed results (i.e., hyetographs and hydrographs) from several storm events at several sites. Unfortunately, all but the latest reports are out of print and available only for short-term loan from the Houston offices of the USGS.

The data have been used in studies of the effect of urbanization in the Houston area (e.g., 166, 167). Data from Hunting Bayou have been used for ILLUDAS model calibration (50). Data from several Houston catchments along with many others were used by Brater and Sherrill (168) to develop unit hydrograph parameters. Keypunched data for the four catchments included herein were obtained from this latter study. Similar studies in urban hydrology are underway in Austin and Dallas.

The quality of these data are good. The measurements are carefully conducted, and the annual reports (164, 165) give a detailed time history of each storm. Quality sampling at several locations is now underway as a part of EPA 208 studies.

It is anticipated that quality data from the Woodlands project (80, 169) north of Houston will be included in addenda to the data base. Extensive quality data have been gathered; they await complete computerization before they can be transmitted to UF.

State and City Code: TX 01

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

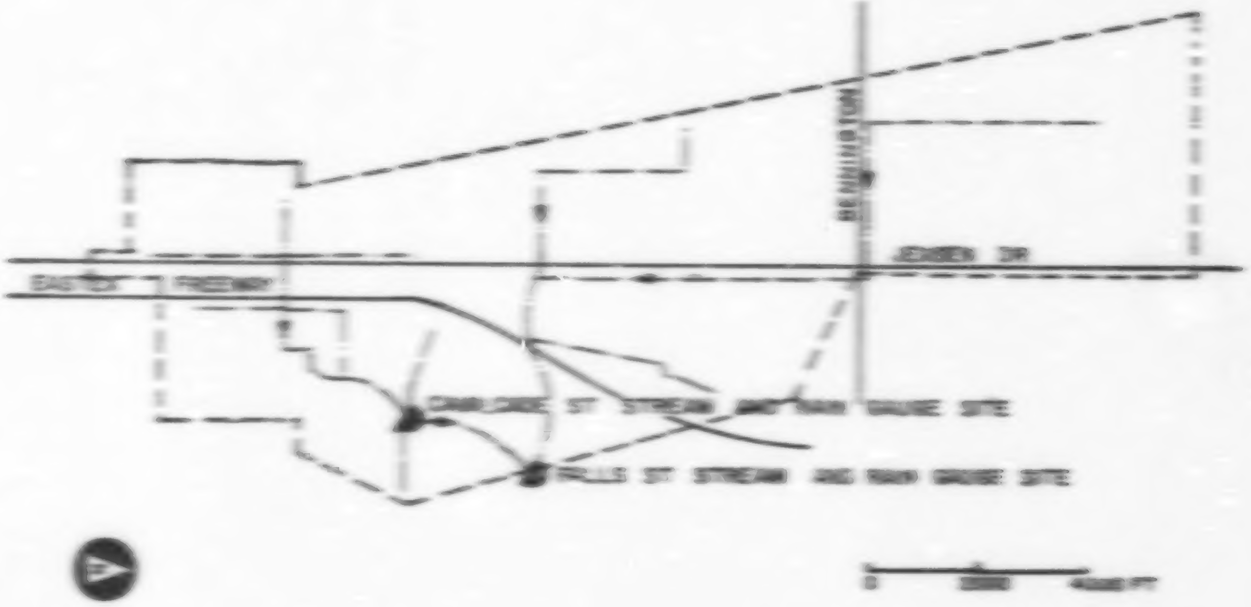
Table VIII-31. Quantity Data - Houston

		Flow		Rain					
				Gages Used					
No.	Catchment	Type of Flow meas.	Sampling Interval, min	No. in Catchment	No. near Catchment	Type	Sampling Interval, min	No. of Storms	Period
1	Hunting Bayou at Cavalcade St.	f_1	15-60	1	2	r_1	10-60	8	5/65-9/68
2	Hunting Bayou at Falls St.	f_1	15-60	2	1	r_1	10-60	11	5/65-11/69
3	Bering Ditch at Woodway Dr.	f_1	15-60	1	-	r_1	10-60	10	12/64-9/68
4	Berry Creek at Galveston Rd.	f_1	15-60	1	2	r_1	10-60	10	11/64-9/68

f_1 - Stage measurements with stage-discharge rating curve.

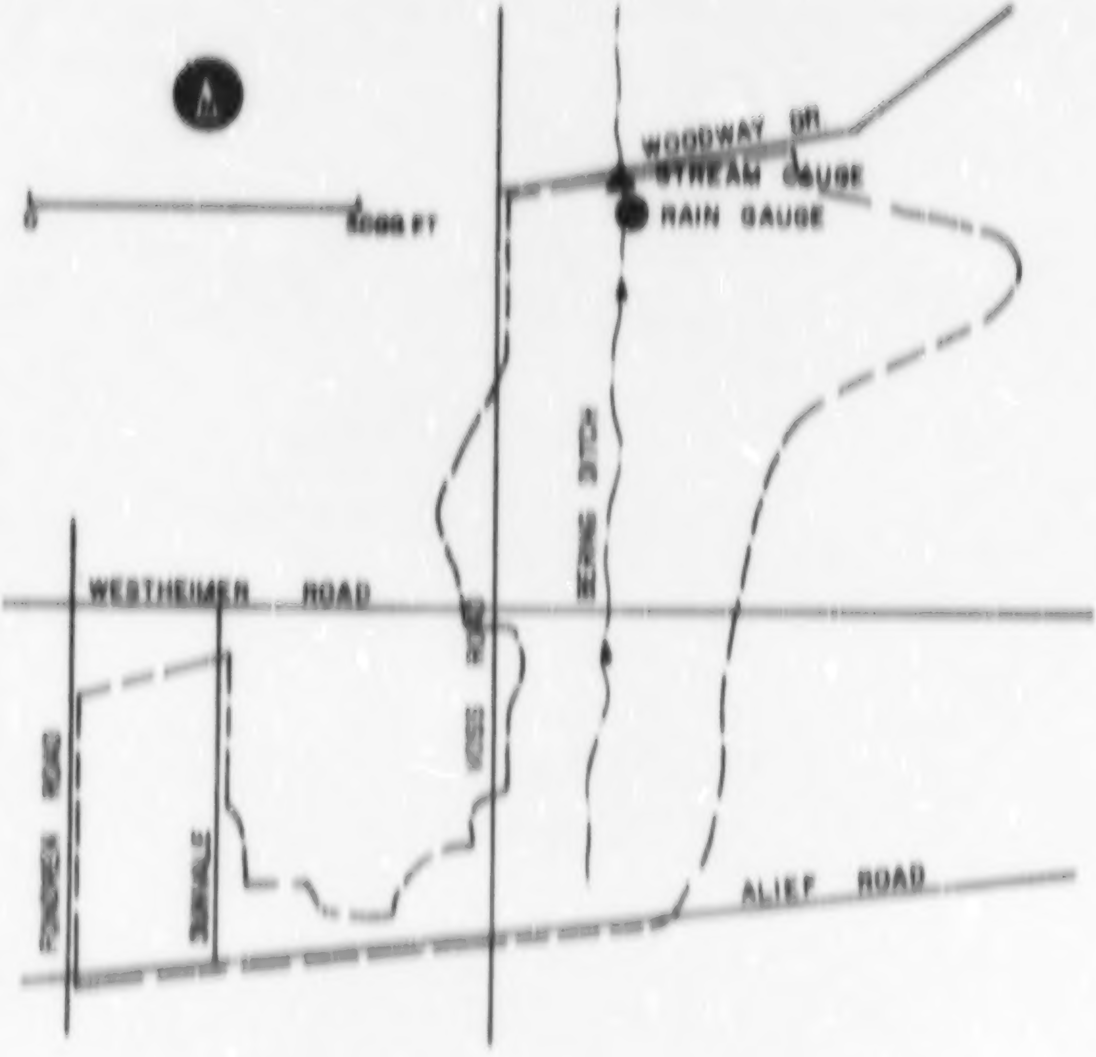
r_1 - USGS Type SR continuous rain gage.

Time synchronization, rain-flow: Good, since most storms utilize rainfall data measured at same location as flow.


EASTEX FREEWAY
JENSEN DR
BENNINGTON
CAVALCADE ST STREAM AND RAIN GAUGE SITE
FALLS ST STREAM AND RAIN GAUGE SITE
0
2000
4000 FT

HOUSTON , TEXAS
HUNTING BAYOU SUBCATCHMENTS
CAVALCADE ST (TX 1 1) FALLS ST (TX 1 2)

Figure VIII-14 Houston, Texas, Hunting Bayou at Cavalcade St. Catchment, and Hunting Bayou at Falls St. Catchment, 768 ac (311 ha).


WOODWAY DR
STREAM GAUGE
RAIN GAUGE
0
5000 FT
BERING DITCH
WESTHEIMER ROAD
ALIEF ROAD

HOUSTON TEXAS
BERING DITCH AT WOODWAY DRIVE CATCHMENT
(TX 1 3)

Figure VIII-15 Houston, Texas, Bering Ditch Catchment, 1894 ac (767 ha).

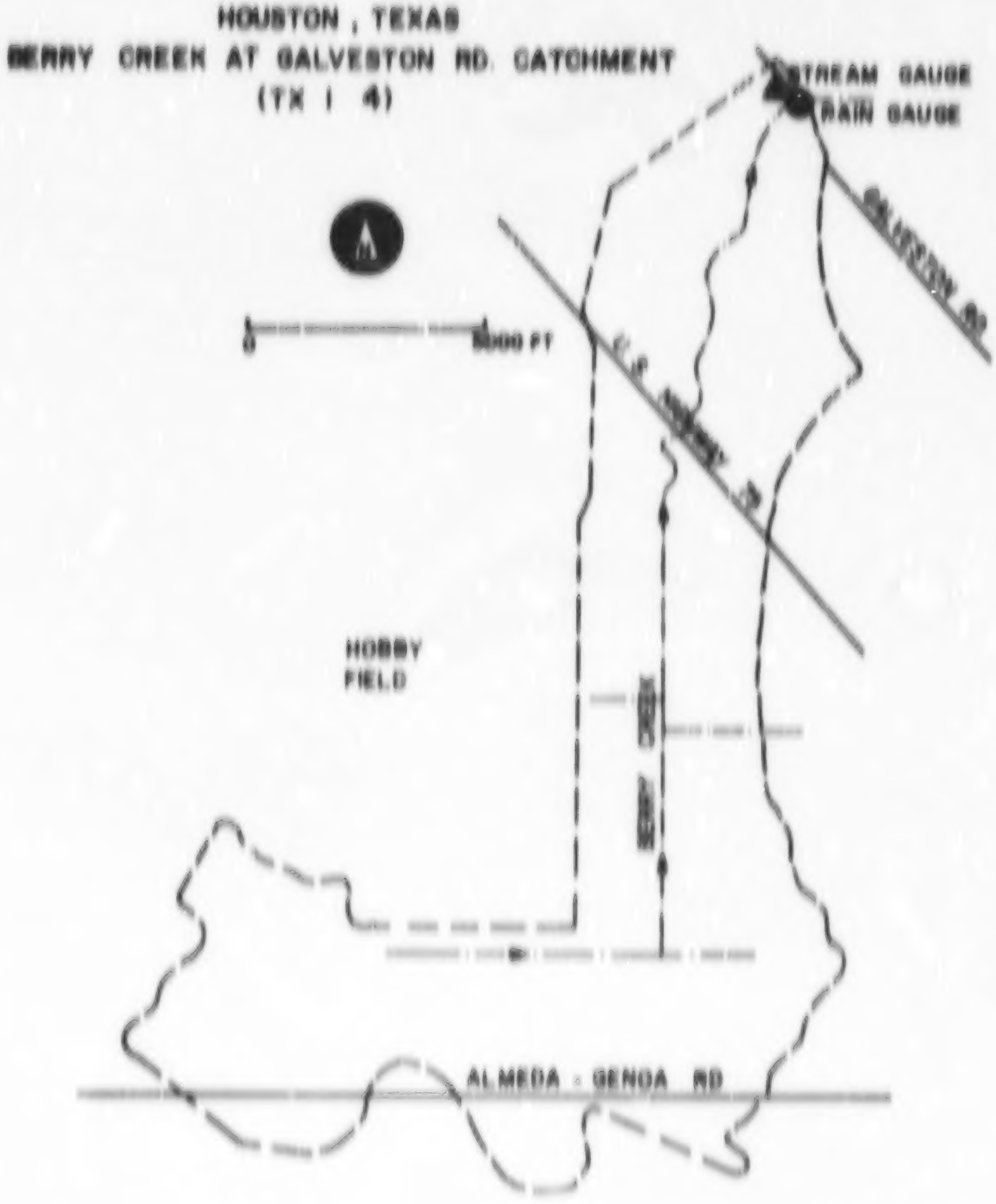

HOUSTON , TEXAS
BERRY CREEK AT GALVESTON RD. CATCHMENT
(TX I 4)
STREAM GAUGE
RAIN GAUGE
GALVESTON RD
0
5000 FT
U.S. HIGHWAY 35
HOBBY
FIELD
BERRY CREEK
ALMEDA - GENOA RD

Figure VIII-16 Houston, Texas, Berry Creek Catchment, 3110 ac (1259 ha).

SECTION IX

DISSEMINATION, MAINTENANCE AND UPDATING

DISSEMINATION

The format of the magnetic tape containing the data was described in Section VI. As discussed, retrieval of the data can take the form of a listing or various searches for desired parameters. No special software is required since the tape is merely a substitute for input from punched cards. Copies of the tape will be mailed by UF at cost (anticipated to be about $40) to those who request it. It is possible that the tape may also be made available through the National Technical Information Service (NTIS).

The data will also be placed on the EPA STORET data management system. This will facilitate access by a wide variety of users and make available STORET software for analysis purposes.

In-house modeling data varies in quantity from location to location. They generally consist of maps, photos, drainage plans and written descriptions of each location, but few sites have all such material. Available data will be made available on a loan basis for short time periods. Future refinements may include placing maps, plans, etc. on a microfiche file.

MAINTENANCE AND UPDATING

As indicated in Section V, many data sources already extant may be suitable for inclusion in the data base. In addition, there are presently underway approximately 150 EPA Section 208 Areawide Waste Management Studies, many of which are collecting storm event data of the type included in this report. As such sources are developed, periodic addenda to this report will be issued. These will consist primarily of documentation for new sources of the nature of that found in Sections VII and VIII. Simultaneously, the data will be placed on the magnetic tape with the previous sources. Updating of the tape for previous sources will also include addition of new storm events to those already included on the tape. Any changes in catchment parameters (e.g., imperviousness, population) will also be noted.

Future project work at UF includes elementary statistical analyses of the data. These will include computation of ranges, means, medians, variances, etc. of the data with allowance for flow weighting. Some computations will be performed to develop mass loadings of the type discussed in Section III.

REFERENCES

1. Brandstetter, A. "Assessment of Mathematical Models for Storm and Combined Sewer Management," EPA Report EPA-600/2-76-175a, August 1976.

2. Huber, W.C. "Modeling for Storm Water Strategies," APWA Reporter, Vol. 42, No. 5, pp. 10-14, May 1975.

3. U.S. National Weather Service, Substation Observations. Observers Handbook, No. 2, 1970, Rev. 1972.

4. World Meteorological Organization. Guide to Hydrometeorological Practices, 2nd ed., WMO No. 168, Tech. Paper 82, Geneva, 1970.

5. Linsley, R.K., Kohler, M.A. and Paulhus, J.L.H. Hydrology for Engineers, Second Edition, McGraw-Hill, 1975.

6. Eagleson, P.S. and Shack, W.J. "Some Criteria for the Measurement of Rainfall and Runoff," Water Resources Research, Vol. 2, No. 3., pp.427-436, 1966.

7. Hydrologic Engineering Center, Corps of Engineers. "Storage, Treatment, Overflow and Runoff Model, STORM," Users Manual, Generalized Computer Program 723-58-L7520, Davis, California, July 1976.

8. Smith, G.F. "Adaptation of the EPA Storm Water Management Model for Use in Preliminary Planning for Control of Urban Storm Runoff," M.E. Thesis, Dept. of Environmental Engineering Sciences, University of Florida, Gainesville, 1975.

9. National Weather Service. Local Climatological Data plus supplements, U.S. Dept. of Commerce. Published monthly for each state with additional data available from National Climatic Center, Asheville, North Carolina.

10. Eagleson, P.S. "Optimum Density of Rainfall Networks," Water Resources Research, Vol. 3, No. 4., pp. 1021-1033, 1967.

11. Rodrigues-Iturbe, I. and Mejia, J.M. "The Design of Rainfall Networks in Time and Space," Water Resource Research, Vol. 10, No. 4, pp. 713-728, August 1974.

12. Rodriguez-Iturbe, I. and Mejia, J.M. "On the Transformation of Point Rainfall to Areal Rainfall," Water Resources Research, Vol. 10, No. 4, pp. 729-736, August 1974.

13. U.S. Geological Survey, "Recommended Methods for Water-Data Acquisition," Preliminary Report of the Federal Interagency Work Group on Designation of Standards for Water Data Acquisition, 1972.

14. Buchanan, T.J. and Somers, W.P. "Stage measurement at gaging stations," USGS Techniques of Water-Resources Inv., Book 3, Chap. A7, 1968.

15. Buchanan, T.J. and Somers, W.P. "Discharge measurements at gaging stations," USGS Techniques of Water-Resources Inv., Book 3, Chap. A8, 1969.

16. Kilpatrick, F.A. "Use of flumes in measuring discharge at gaging stations," USGS Surface-Water Techniques, Book 1, Chap. 16, 1965.

17. Carter, R.W. and Davidian, J. "Discharge ratings at gaging stations," USGS Surface-Water Techniques, Book 1, Chap. 12, 1965.

18. Gray, D.M., ed. *Handbook on the Principles of Hydrology*, Water Information Center, 1973.

19. Chow, V.T. *Open-Channel Hydraulics*, McGraw-Hill, 1959.

20. Knapp, J.W., Schaake, J.C. and Viessman, W. Jr. "Measuring Rainfall and Runoff at Storm-Water Inlets," J. Hyd. Div., Proc. ASCE, Vol. 89, No. HY5, pp. 99-115, September 1963.

21. Wenzel, H.G. Jr. "A Critical Review of Methods of Measuring Discharge Within a Sewer Pipe," ASCE Urban Water Resources Research Program, Tech. Memo. No. 4, NTIS-PB 182 789, September 1968.

22. Shelley, P.E. and Kirkpatrick, G.A. "Sewer Flow Measurement--A State of the Art Assessment," EPA Report EPA-600/2-75-027, NTIS-PB 250 371, November 1975.

23. Wullschleger, R.E., Zanoni, A.E. and Hansen, C.A. "Methodology for the Study of Urban Storm Generated Pollution and Control," EPA Report EPA-600/2-76-145, August 1976.

24. Parshall, R.L. "The Improved Venturi Flume," Transactions ASCE, Vol. 89, pp. 841-851, 1926.

25. Dickin, M.H. "Temporary Flow Measurements in Sewers and Drains," J. Hyd. Div., Proc. ASCE, Vol. 89, No. HY4, pp. 141-150, July 1963.

26. Smoot, G.F., Davidian, J. and Billings, R.H. "Urban Storm Rainfall-Runoff-Quality Instrumentation," IASH Publ. No. 112, p. 44, 1974.

27. Shelley, P.E. and Kirkpatrick, G.A. "Assessment of Automatic Sewer Flow Samplers--1975," EPA Report EPA-600/2-75-065, NTIS-PB 250 987, December 1975.

28. Shelley, P.E. "Design and Testing of a Prototype Automatic Sewer Sampling System," EPA Report EPA-600/2-76-006, NTIS-PB 252 613, March 1976.

29. American Public Health Assn., American Public Works Assn., Water Pollution Control Federation. Standard Methods for the Examination of Water and Wastewater, 14th Edition, American Public Health Assn., Washington, D.C., 1975.

30. Environmental Protection Agency. "Water Quality Control Information System (STORET) Handbook," Washington,D.C., 1965 with updates.

31. Lager, J.A. and Smith, W.G. "Urban Stormwater Management and Technology: An Assessment," EPA Report EPA-670/2-74-040, NTIS-PB 240 687, December 1974.

32. Milwaukee, City of, Department of Public Works Milwaukee. "Detention Tank for Combined Sewer Overflow--Milwaukee, Wisconsin, Demonstration Project." EPA Report EPA-600/2-75-071, NTIS-PB 250 427, December 1975.

33. Municipality of Metropolitan Seattle (METRO) and River Basin Coordinating Committee. "Environmental Management for the Metropolitan Area, Part II Urban Drainage, Appendix C Storm Water Monitoring Program," Seattle, October 1974.

34. Engineering-Science, Inc. "Characterization and Treatment of Combined Sewer Overflows," Final Report to City and County of San Francisco, EPA Report EPA-670/2-75-114, NTIS-PB 241 299, April 1975.

35. Engineering-Science, Inc. "Dissolved Air Flotation, Appendix A, Phase I--Pre-Construction Studies on Quality and Quantity Relationships of Combined Sewage Flows and Receiving Water Studies at Outer Marina Beach," City and County of San Francisco report for EPA, July 1971.

36. Tucker, L.S. "Northwood Gaging Installation, Baltimore--Instrumentation and Data," ASCE Urban Water Resources Research Program, Tech. Memo. No. 11, NTIS-PB 182 786, August 1968.

37. Tucker, L.S. "Oakdale Gaging Installation, Chicago--Instrumentation and Data," ASCE Urban Water Resources Research Program, Tech. Memo No. 2, NTIS-PB 182 787, August 1968.

38. Tucker, L.S. "Raingage Networks in the Largest Cities," ASCE Urban Water Resources Research Program, Tech. Memo No. 9, NTIS-PB 184 704, March 1969.

39. Tucker, L.S. "Non-Metropolitan Dense Raingage Networks," ASCE Urban Water Resources Research Program, Tech. Memo No. 11, NTIS-PB 191 709, January 1970.

40. Tucker, L.S. "Availability of Rainfall-Runoff Data for Sewered Catchments," ASCE Urban Water Resources Research Program, Tech. Memo No. 8, NTIS-PB 184 703, March 1969.

41. Tucker, L.S. "Sewered Drainage Catchments in Major Cities," ASCE Urban Water Resources Research Program, Tech. Memo No. 10, NTIS-PB 184 705, March 1969.

42. Tucker, L.S. "Availability of Rainfall-Runoff Data for Partly Sewered Urban Drainage Catchments," ASCE Urban Water Resources Research Program, Tech. Memo No. 13, NTIS-PB-191 755, March 1970.

43. Roesner, L.A., Nichandros, H.M., Shubinski, R.P., Feldman, A.D., Abbot, J.W. and Friedland, A.O. "A Model for Evaluating Runoff-Quality in Metropolitan Master Planning," ASCE Urban Water Resources Research Program, Tech. Memo No. 23, NTIS-PB 234 312, April 1974.

44. McPherson, M.B. and Mangan, G.F. Jr. "ASCE Urban Water Resources Research Program," J. Hyd. Div. Proc. ASCE, Vol 101, No. HY7, pp.847-855, July 1975.

45. McPherson, M.B. "Urban Hydrological Modeling and Catchment Research in the U.S.A.," ASCE Urban Water Resources Research Program, Tech. Memo No. IHP-1, NTIS-PB 260 685, November 1975.

46 Aitken, A.P. "Urban Hydrological Modeling and Catchment Research in Australia," ASCE Urban Water Resources Research Program, Tech. Memo No. IHP-2, NTIS-PB 260 686 , May 1976.

47. Marsalek, J. "Urban Hydrological Modeling and Catchment Research in Canada," ASCE Urban Water Resources Research Program, Tech. Memo No. IHP-3, NTIS-PB 262 068, June 1976.

48. Lowing, M.J. "Urban Hydrological Modeling and Catchment Research in the United Kingdom," ASCE Urban Water Resources Research Program, Tech. Memo No. IHP-4, NTIS-PB 262 069, July 1976.

49. Stall, J.B. and Terstriep, M.L. "Storm Sewer Design--An Evaluation of the RRL Method," EPA Report EPA-R2-72-068, NTIS-PB 214 134, October 1972.

50. Terstriep, M.L. and Stall, J.B. "The Illinois Urban Drainage Area Simulator, ILLUDAS," State of Illinois, Illinois State Water Survey, Bulletin 58, Urbana, 1974.

51. U.S. Geological Survey, "Catalog of Information on Water Data," Edition 1974, Separate volumes for each of 21 regions.

52. Schneider, W.J. "Water Data for Metropolitan Areas," USGS Water Supply Paper 1871, 1968.

53. Water Resources Scientific Information Center. "Catalog of USGS Publications Related to Urban Water Resources 1968--November 1974," Report for USGS, 1974.

54. U.S. Geological Survey. "WATSTORE Users Guide," Water Resources Division, Reston, Va., 1975.

55. Edwards, M.D. "Status of the National Water Data Exchange (NAWDEX)--September 1976," USGS Open File Report 76-719, Reston, Va., 1976.

56. Anderson, D.R. "Water Quality Models for Urban and Suburban Areas," Completion Report, OWRT Project No. A-025NEB, University of Nebraska, Lincoln, NTIS-PB 238 622, August 1974.

57. Heaney, J.P., Huber, W.C., Medina, M.A., Nix, S.J., Murphy, M.P. and Hasan, S. "Nationwide Evaluation of Combined Sewer Overflows and Stormwater Discharges: Vol. II Cost Assessment and Impacts," EPA Report 600/2-77-064b, March 1977.

58. Burford, J.B. and Clark, J.M. "Hydrologic Data for Experimental Agricultural Watersheds in the United States, 1967," Agricultural Research Service, Misc. Publ. No. 1262, GPO No. 0100-02802, July 1973.

59. NOAA, Environmental Data Service, "Users Guide to ENDEX/OASIS, Environmental Data Index and the Oceanic and Atmospheric Scientific Information System," Key to Oceanic and Atmospheric Information Sources No.1, Washington D.C., January 1976.

60. U.S. National Committee for the International Hydrological Decade. "International Hydrological Decade Representative and Experimental Basins in the United States, Catalog of Available Data and Results, 1965-1972," Report NAS/IHD-74/01 for National Academy of Sciences, NTIS-PB 237 002, July 1974.

61. National Technical Information Service. "Directory of Computerized Data Files and Related Software Available from Federal Agencies," NTIS-SR-74-01, March 1974.

62. Proctor and Redfern Ltd. and James F. MacLaren Ltd. "Storm Water Management Model Study, Vol. I," COA Research Report 47, Environmental Protection Service, Ottawa, Ontario, K1A 0H3, September 1976.

63. Proctor and Redfern Ltd. and James F. MacLaren Ltd. "Storm Water Management Model Study, Vol. II," COA Research Report 48, Environmental Protection Service, Ottawa, Ontario, K1A 0H3, September 1976.

64. Black, Crow and Eidsness, Inc. "Storm and Combined Sewer Pollution Sources and Abatement, Atlanta, Ga.," EPA Report EPA-11024ELB01/71, NTIS-PB 201 725, January 1971.

65. Holbrook, R.F., Perez, A.I., Turner, B.G. and Miller, H.J. "Stormwater Studies and Alternatives in Atlanta," J. Env. Eng. Div.,Proc. ASCE, Vol. 102, No. EE6, pp. 1263-1277, December 1976.

66. Marsalek, J. "Malvern Urban Test Catchment," Progress Report No. 1, Project 73-3-12, Canada Centre for Inland Waters, Burlington, Ont. L7R 4A6, April 1976.

67. Marsalek, J. Canada Centre for Inland Waters, "Storm Water Quality in the Malvern Catchment," Paper presented at SWMM Users Group Meeting, Toronto, October 1976.

68. Cincinnati, University of. "Urban Runoff Characteristics," EPA Report EPA-11024DQU10/70, NTIS-PB 202 865, October 1970.

69. Weibel, S.R., Anderson, R.J. and Woodward, R.L. "Urban Land Runoff as a Factor in Stream Pollution," JWPCF, Vol. 36, No. 7, pp. 914-924, July 1964.

70. Havens and Emerson, Ltd. "Master Plan for Pollution Control, Report to City of Cleveland," 1967.

71. Urban Drainage and Flood Control District. "Denver Region Urban Hydrology Report," Technical Series, Denver, undated.

72. Ducret, G.L. Jr. and Hodges, H.E. "Rainfall-Runoff data from Small Watersheds in Colorado, June 1968 through September 1971," USGS, Urban Drainage and Flood Control Dis. and Colo. Dept. of Highways, Colorado Water Resources Basic-Data Release No. 27, Colorado Water Conservation Board, Denver, 1972.

73. Davis, P.L. and Borchardt, F.A. "Combined Sewer Overflow Abatement Plan, Des Moines, Iowa," EPA Report EPA-R2-73-170, April 1974.

74. Jewell, T.K., Mangarella, P.A. and DiGiano, F.A. University of Massachusetts, "Application and Testing of the EPA Stormwater Management Model to Greenfield Massachusetts," presented at National Symposium on Urban Rainfall and Runoff and Sediment Control, University of Kentucky, Lexington, Ky., July 1974.

75. Waller, D.H. "Pollution Attributable to Surface Runoff and Overflows from Combined Sewerage Systems," Central Mortgage and Housing Corporation, Ottawa, Ontario , April 1971.

76. Bhatia, I. "Mass Discharge Rates and Variations in Composition of Surface Runoff from two Urban Areas," M.S. thesis, Dept. of Civil Engineering, Nova Scotia Technical College, Halifax, 1973.

77. Waller, D.H., Coulter, W.A., Carson, W.M., and Bishop, D.G. "Urban Drainage Model Comparison for a Catchment in Halifax, Nova Scotia," COA Research Report No. 43, Environmental Protection Service, Ottawa,

Ontario, K1A 0H3, 1976.

78. Waller, D.H. and Coulter, W.A. "Winter Runoff from an Urban Catchment," COA Research Report No. 41, Environmental Protection Service, Ottawa, Ontario, K1A 0H3, 1976.

79. Richer, C.V., Gore and Storrie Ltd. "Description of an Urban Test Catchment in Hamilton Ontario," Presented at SWMM Users Group Meeting, Toronto, April 1976.

80. Characklis, W.G., Gaudet, F.J., and Roe, R.L. "Maximum Utilization of Water Resources in a Planned Community," Rice Univ., Report to Edison Water Quality Research Laboratory, EPA, Edison, N.J., June 1976.

81 James F. MacLaren, Ltd. "Review of Canadian Storm Sewer Design Practice and Comparison of Urban Hydrologic Models," COA Research Report No. 26, Environmental Protection Service, Ottawa, Ontario, K1A 0H3, 1975.

82. Kidd, C.H.R. "The Development of an Urban Runoff Model," MS. Thesis, Dept. of Civil Engineering, Queen's University, Kingston, Ontario, 1972.

83. Eagleson, P.S. "Unit Hydrograph Characteristics for Sewered Areas," J. Hyd. Div., Proc. ASCE, Vol. 88, No. HY2, pp. 1-25, March 1962.

84. Corps of Engineers. "Report of Sewer Runoff Investigation for Louisville, Kentucky," Louisville District, Louisville, Ky, 1949.

85. Wells, D.M., Anderson, J.F., Sweazy, R.M. and Claborn, B.J. "Variation of Urban Runoff Quality with Duration and Intensity of Storms--Phase II," OWRT Completion Report, Project OWRR B-104-TEX, Texas Tech University, Lubbock, NTIS-PB 223 930, August 1973.

86. Grizzard, T.J., Hartigan, J.P., Randall, C.W. and Kim, J.I. Virginia Polytechnic Institute, "Assessment of Runoff Pollution Impacts in Urbanizing Watershed: A Case Study of Northern Virginia's Occoquan Watershed," Presented at the EPA Region III Urban Runoff Seminar, Philadelphia, November 1976.

87. Wanielista, M.P. "Nonpoint Source Effects," Florida Technological University, Orlando, Report No. ESEI-76-1 to State Dept. of Environmental Regulation, Tallahassee, January 1976.

88. Wanielista, M.P. "Nonpoint Source Effects, Appendices," Florida Technological University, Orlando, Report No. ESEI-76-2, to State Dept. of Environmental Regulation, Tallahassee, January 1976.

89. Wanielista, M.P., ed. "Nonpoint Source Workshop," Florida Technological University, Orlando, Report No. ESEI-76-3, to State Dept. of Environmental Regulation, Tallahassee, February 1976.

90. Turner, R.R., Harriss, R.C., Burton, T.M. and Laws, E.A. "The Effect of Land Use on Nutrient Fluxes in North Florida Watersheds," Dept. of Oceanography, Florida State Univ., Tallahassee, 1975.

91. Proctor and Redfern Ltd. and James F. MacLaren Ltd. "Storm Water Management Model Study, Volume III," COA Research Report, Environmental Protection Service, Ottawa, Ontario, K1A 0H3, September 1976.

92. James F. MacLaren Ltd. "Report on the Brucewood Monitoring Programme, Feb. 15, 1974–December, 1974," Report and Addendum to Canada Centre for Inland Waters, Burlington, Ontario, L7R 4A6, September 1975.

93. James F. MacLaren Ltd. "Brucewood Monitoring Programme, January 1, 1975, to May 15, 1975," Report to Canada Centre for Inland Waters, Burlington, Ontario, L7R 4A6, December 1975.

94. Larson, E., M.M. Dillon Ltd. "Instrumentation of an Urban Catchment in Metropolitan Toronto," Presented at SWMM Users Group Meeting, Toronto, April 1976.

95. James F. MacLaren Ltd. "A Study of Environmental Problems at Toronto International Airport," Prepared for the Environmental Protection Service, Ontario Region, July 1975.

96. Resnick, S.D. and DeCook, K.J. "Hydrological and Environmental Controls on Water Management in an Arid Urban Area," Symp. on Urbanization in the Arid Lands, Dec., 1970. ICASALS Publ. 75-1, Texas Tech University, Lubbock, 1974.

97. Blackwood, K.R. "Runoff Water Quality of Three Tucson Watersheds," Research Report, Dept. of Civil Eng., Univ. of Arizona, Tucson, 1974.

98. Dharmadhikari, V.V. "Quality of Runoff from Diversified Urban Watersheds," MS. Thesis, Dept. of Civil Eng., Univ. of Arizona, Tucson, 1970.

99. Mische, E.F. "The Potential of Urban Runoff as a Water Resource," PhD Dissertation, Dept. of Civil Eng., Univ. of Arizona, Tucson, 1971.

100. Weston, R.F. "Conceptual Engineering Report—Kingman Lake Project," EPA Report EPA-11023FIX08/70, NTIS-PB 197 598, August 1970.

101. Metcalf & Eddy Engineers, University of Florida and Water Resources Engineers. "Storm Water Management Model, Vol. I, Final Report," EPA Report EPA-11024DOC07/71, NTIS-PB 203 289, July 1971.

102. Metcalf & Eddy Engineers, University of Florida and Water Resources Engineers. "Storm Water Management Model, Vol. II, Verification and Testing," EPA Report EPA-11024DOC08/71, NTIS-PB 203 290, August 1971.

103. Huber, W.C., Heaney, J.P., Medina, M.A., Peltz, W.A., Sheikh, H. and Smith, G.F. "Storm Water Management Model: User's Manual--Version II," EPA Report EPA-670/2-75-017, March 1975.

104. Sherwood, C.B. and Mattraw, H.C.Jr."Quantity and Quality of Runoff from a Residential Area Near Pompano Beach, Florida," in Proceedings, Storm-Water Management Workshop, M.P. Wanielista, ed., Florida Technological University, Orlando, February 1975.

105. Mattraw, H.C. Jr. and Sherwood, C.B. "Quality of Storm-Water from a Residential Area, Broward County, Florida," Journal of Research of the U.S. Geological Survey, Vol. 5, (in press), 1977.

106. Heaney, J.P., Huber, W.C., Sheikh, H., Medina, M.A., Doyle, J.R., Peltz, W.A. and Darling, J.E. "Urban Stormwater Management Modeling and Decision-Making," EPA Report EPA-670/2-75-022, NTIS-PB 242 290, May 1975.

107. Hergert, S.L. "Urban Runoff Quality and Modeling Study," MS. Thesis, Dept. of Civil Engineering, University of Nebraska, Lincoln, NTIS-PB 237 161, December 1972.

108. Clark, M.J., Gruber, D.A., Meinholz, T.L., Moser, J.H., Race, R.A. and Hansen, C.A. "Screening/Dissolved-Air Flotation Treatment as an Alternative to Combined Sewer Separation," EPA Report in preparation, 1977.

109. Corps of Engineers. "Environmental Management for the Metropolitan Area Cedar-Green River Basins, Washington, Part II Urban Drainage, Appendix B Urban Storm Drainage Simulation Models," Report for River Basin Coordinating Committee by Kramer, Chin and Mayo; Water Resources Engineers and Yoder, Trotter Orlob and Assoc., Seattle, December 1974.

110. Droste, R.L. "Pollution Loadings of Urban Storm Runoff," M. Appl. Sc.Thesis, Dept. of Civil Engineering, University of Windsor, Windsor, Ontario, July 1974.

111. Singh, M.M. "Urban Storm Runoff, A Qualitative and Quantitative Study," M. Appl. Sc. Thesis, Dept. of Civil Engineering, University of Windsor, Windsor, Ontario, March 1972.

112. Chen, C.W. and Shubinski, R.P. "Computer Simulation of Urban Storm Water Runoff," J. Hyd. Div.,Proc. ASCE, Vol. 97, No. HY2, pp. 289-301, February 1971.

113. Terstriep, M.L. and Stall, J.B. "Urban Runoff by Road Research Laboratory Method," J. Hyd. Div.,Proc. ASCE, Vol. 95, No. HY6, pp. 1809-1834, November 1969.

114. Miller, C.R. "Runoff Yields from Small Urban Watersheds," MS. Thesis, Dept. of Civil Engineering, University of Nebraska, Lincoln, January 1971.

115. Miller, C.R. and Viessman, W. Jr. "Runoff Volumes from Small Urban Watersheds," Water Resources Research, Vol. 8, No. 2, pp. 429-434, April 1972.

116. Schaake, J.C. Jr., Leclerc, G. and Harley, B.M. "Evaluation and Control of Urban Runoff," ASCE Annual and National Environmental Engineering Meeting, New York, Preprint 2103, October 1973.

117. Surkan, A.J. and Kelton, P. "Binary Tree Model Simulation of the Behavior of Urban Hydrologic Systems," Int. J. Systems Science, Vol. 5, No. 7, pp. 639-654, July 1974.

118. Shubinski, R.P. and Roesner, L.A. Water Resources Engineers, "Linked Process Routing Models," Presented at Symposium on Models for Urban Hydrology, Spring Meeting, American Geophysical Union, Washington, D.C., April 1973.

119. Marsalek, J., Dick, T.M., Wisner, P.E. and Clarke, W.G. "Comparative Evaluation of Three Urban Runoff Models," Water Resources Bulletin, Vol. 11, No. 2, pp. 306-328, April 1975.

120. Viessman, W. Jr. and Geyer, J.C. "Characteristics of the Inlet Hydrograph," J. Hyd. Div., Proc. ASCE, Vol. 88, No. HY5, pp. 245-267, September 1962.

121. Willeke, G.E. "Time in Urban Hydrology," J. Hyd. Div.,Proc. ASCE, Vol. 92, No. HY1, pp. 13-29, January 1966.

122. Schaake, J.C. Jr., Geyer, J.C. and Knapp, J.W. "Experimental Examination of the Rational Method," J. Hyd. Div., Proc. ASCE, Vol. 93, No. HY6, pp. 353-370, November 1967.

123. Grace, R.A. and Eagleson, P.S. "Scale Model of Urban Runoff from Storm Rainfall," J. Hyd. Div., Proc. ASCE, Vol. 93, No. HY3, pp. 161-176, May 1967.

124. Grace, R.A. and Eagleson, P.S. "The Modeling of Overland Flow," Water Resources Research, Vol. 2, No. 3, pp. 393-403, 1966.

125. Harley, B.M., Perkins, F.E. and Eagleson, P.S. "A Modular Distributed Model of Catchment Dynamics," MIT Parsons Lab Report No. 133, December 1970.

126. Klym, H., Koniger, W., Mevius, F. and Vogel, G. Dorsch Consult, "Urban Hydrological Processes, Computer Simulation," Presented at the Seminar or Computer Methods in Hydraulics, Swiss Federal Institute, Zurich, February 1972.

127. Colyer, P.J. and Pethick, R.W. "Storm Drainage Design Methods, a Literature Review," Report No. INT 134, Hydraulics Research Station, Wallingford, Oxfordshire, England, March 1976.

128. Chow, V.T., and Yen, B.C. "Urban Stormwater Runoff--Determination of Volumes and Flowrates," EPA Report EPA-600/2-76-116, NTIS-PB 253 410, May 1976.

129. Papadakis, C.N. and Preul, H.C. "Testing of Methods for Determination of Urban Runoff," J. Hyd. Div., Proc. ASCE, Vol. 99, No. HY9, pp. 1319-1335, September 1973.

130. Brown, J.W. and Suhre, D. "Sewer Monitoring and Remote Control--Detroit," ASCE Annual and Environmental Meeting, Chicago, Preprint No. 1035, October 1969.

131. Stall, J.B., Terstriep, M.L. and Huff, F.A. "Some Effects of Urbanization on Floods," ASCE National Water Resources Engineering Meeting, Memphis, Preprint No. 1130, January 1970.

132. Burgess and Niple, Ltd. "Stream Pollution and Abatement from Combined Sewer Overflows, Bucyrus, Ohio," EPA Report EPA 11024FKN11/69, NTIS-PB 195 162, November 1969.

133. Bryan, E.H. "Quality of Stormwater Drainage from Urban Land Areas in North Carolina," Report No. 37, Water Resources Research Institute, University of North Carolina, Raleigh, 1970.

134. Bryan, E.H. "Quality of Stormwater Drainage from Urban Land," Water Resources Bulletin, Vol. 8, No. 3, pp. 578-588, June 1972.

135. Smith, R. and Eilers, R.G. "Control Schemes for the Activated-Sludge Process," EPA Report EPA-670/2-74-069, NTIS-PB 236 006, December 1974.

136. Wilson, K.V. "A Preliminary Study of the Effect of Urbanization on Floods in Jackson, Mississippi," USGS Professional Paper 575-D, pp. 259-261, 1968.

137. Seaburn, G.E. "Preliminary Results of Hydrologic Studies at Two Recharge Basins on Long Island, New York," USGS Professional Paper 627-C, 1970.

138. Seaburn, G.E. "Method of Rating Flow in a Storm Sewer," USGS Professional Paper 750-D, pp. D219-D223, 1971.

139. Seaburn, G.E. "Effects of Urban Development on Direct Runoff to East Meadow Brook, Nassau County, Long Island, New York," USGS Professional Paper 627-B, 1969.

140. Guarino, C.F., Radziul, J.V. and Greene, W.L. "Combined Sewer Considerations by Philadelphia," J. San. Eng. Div., Proc. ASCE, Vol. 96, No. SA1, pp. 1-14, February 1970.

141. Hagerman, J.A., and Dressler, F.R. "Storm Water Management Model: Dissemination and User Assistance," EPA Report EPA-670/2-75-041,

NTIS-PB 242 544, May 1975.

142. Crawford, N.H. "Studies on the Application of Digital Simulation to Urban Hydrology," Hydrocomp International, Palo Alto, California, NTIS-PB 206 915, September 1971.

143. DiGiano, F.A. and Mangarella, P.A. "Short Course Proceedings: Applications of Stormwater Management Models," EPA Report EPA-670/2-75-065, NTIS-PB 247 163, June 1975.

144. Huber, W.C., Russell, L.W. and Pyatt, E.E. "Routing Model for Combined Sewage," ASCE National Water Resources Engineering Meeting, Memphis, Preprint 1108, January 1970.

145. Roesner, L.A., Kibler, D.F. and Monser, J.R. "Use of Storm Drainage Models in Urban Planning," Proceedings, National Symposium on Watersheds in Transition, Colorado State University, American Water Resources Assn., Urbana, Illinois, pp. 400-405, 1973.

146. Duff, H.W. and Hsieh, G.C.C. "Seattle Rain-gaging Program and Rainstorm Data," ASCE National Water Resources Engineering Meeting, Memphis, Preprint 1089, January 1970.

147. Lager, J.A., Didriksson, T. and Otte, G.B. "Development and Application of a Simplified Stormwater Management Model," EPA Report EPA-600/2-76-218, NTIS-PB 258 074, August 1976.

148. Massing, H. "Urban Hydrology Studies and Mathematical Modeling in the Federal Republic of Germany," ASCE Urban Water Resources Research Program, Tech. Memo No. IHP-6, NTIS-PB , September 1976.

149. Lind, G. "Urban Hydrological Modeling and Catchment Research in Sweden," ASCE Urban Water Resources Research Program, Tech. Memo No. IHP-7, NTIS-PB , October 1976.

150. Desbordes, M. and Normand, D. "Urban Hydrological Modeling and Catchment Research in France," ASCE Urban Water Resources Research Program, Tech. Memo No. IHP-8, NTIS-PB , November 1976.

151. Selthun, N.R. "Urban Hydrological Modeling and Catchment Research in Norway," ASCE Urban Water Resources Research Program, Tech. Memo No. IHP-9, NTIS-PB , December 1976.

152. Urban Drainage Subcommittee. "Report of the Urban Drainage Subcommittee Program, Urban Drainage Subcommittee, Canada-Ontario Agreement, Describing Projects Conducted Between 1972 and 1976," Training and Technology Transfer Division (Water), Environmental Protection Service, Ottawa, Ontario K1A 0H3, 1976.

153. Heeps, D.P. and Mein, R.G. "Independent Comparison of Three Urban Runoff Models," J. Hyd. Div., Proc. ASCE, Vol. 100, No. HY7, pp. 995-1009, July 1974.

154. Cordery, I. "Quality Characteristics of Urban Storm Water in Sydney, Australia," Water Resources Research, Vol. 13, No. 1, pp. 197-202, February 1977.

155. Coyne and Bellier. "Measurements and Evaluation of Pollutant Loads from a Combined Sewer Overflow," (in English), Coyne and Bellier, Consulting Engineers, 5, rue d'Héliopolis, 75017 Paris, March 1974.

156. Brunner, P.G. "The Pollution of Storm Water Runoff in Separate Systems: Studies with Special Reference to Precipitaiton Conditions in the Lower Alp Region," Water Resources and Sanitary Engineering Dept. Report No. 9, Munich Technical University, 1975. (English translation available from EPA Cincinnati MERC Library).

157. Arnell, V. and Lyngfelt, S. "Beräkningsmodell för simulering av Dagvattenflöde inom Bebyggda Områden," ("Computational Model for Simulating Daily Floods in Urban Areas"), in Swedish, Chalmers University of Technology, Dept. of Hydraulics Report No. 12, Götegorg, Sweden, 1975

158. Arnell, V. and Lyngfelt, S. "Nederbörds-Avrinningsmätningar i Bergsjön, Göteborg 1973-1974," ("Downstream Runoff Measurements of Runoff at Lake Bergsjön, Göteborg 1973-1974"), in Swedish, Chalmers University of Technology, Dept. of Hydraulics, Report No. 13, Götegorg, Sweden, 1975.

159. Fletcher, J.E. and Chen, C.L. "Urban Storm Runoff Inlet Hydrograph Study: Vol. 3, Hydrologic Data for Two Urban Highway Watersheds in the Salt Lake City Area, Utah," FHWA Report No. FHWA-RD-76-118, NTIS-PB 263987, March 1976.

160. Hydrologic Engineering Center. "Annual Report on the Quality of Urban Storm Runoff Entering the San Francisco Bay," Four Reports for Fiscal Years 1972-75, HEC, Corps of Engineers, Davis, California.

161. McElroy, F.T.R., III, Mattox, C.F., Hartman, D.W., Bell, J.M. "Sampling and Analysis of Stormwater Runoff from Urban and Semi-Urban/Rural Watersheds," Purdue University, Water Resources Research Center, Tech. Rept. No. 64, West Lafayette, Indiana, September 1976.

162. Harper and Owes, Assoc. "Preliminary Water Quality Report for the Milwaukee Combined Sewer Overflow Study," Report for the Milwaukee Metropolitan Sewerage District of the County of Milwaukee, in preparation, 1977.

163. O'Neal, W.G., Davis, A.L., and VanDusen, K.W. "Wastewater Collection System Analysis Model, User's Manual," Report for City of Portland by Cornell, Howland, Hayes, Merryfield-Hill, Corvallis, Oregon, March 1976.

164. Johnson, S.L. and Smith, R.E. "Urban Hydrology of the Houston, Texas Metropolitan Area, Compilation of Basic Data, April 1964 to September 1965," Open File Report, U.S. Geological Survey, Water Resources Division, Federal Bldg., 300 E. 8th St., Austin, Texas 78701, 1965.

165. Ranzau, C.E. Jr. "Hydrologic Data for Urban Studies in the Houston, Texas Metropolitan Area, 1974," Open File Report, U.S. Geological Survey, Water Resources Division, Federal Bldg., 300 E. 8th St., Austin, Texas 78701, June 1976.

166. Johnson, S.L. and Sayre, D.M. "Effects of Urbanization on Floods in the Houston, Texas, Metropolitan Area," Water-Resources Investigations 3-73, U.S. Geological Survey, Water Resources Division, Federal Bldg., 300 E. 8th St., Austin, Texas 78701, April 1973.

167. Espey, W.H. Jr. and Winslow, D.E. "Urban Flood Frequency Characteristics," J. Hyd. Div., Proc. ASCE, Vol. 100, No. HY2, pp. 279-293, February 1974.

168. Brater, E.F. and Sherrill, J.D. "Rainfall-Runoff Relations on Urban and Rural Areas," EPA Report EPA-670/2-75-046, NTIS-PB 224 420, May 1975.

169. Everhart, R.C. "New Town Planned Around Environmental Aspects," Civil Engineering, Vol. 43, No. 9, pp. 69-73, September 1973.

170. Watt, T.R., Skrentner, R.G. and Davanzo, A.C. "Sewerage System Monitoring and Remote Control," EPA Report EPA-670/2-75-020, NTIS-PB 242 107, May 1975.

171. Tracor, Inc. "Statistical Analysis of Hydrograph Characteristics for Small Urban Watersheds," Final Report to OWRT, Contract No. 14-13-0001-3737, NTIS-PB 228 131, October 1973.

172. Jennings, M.E. and Mattraw, H.C., Jr. "Comparison of Predictive Accuracy of Models of Urban Flow and Water Quality Processes," Proc. of National Symposium on Urban Hydrology, Hydraulics and Sediment Control, University of Kentucky, Lexington, pp. 239-243, July 1976.

173. Geiger, W.F., LaBella, S.A. and Mc Donald, G.C. "Overflow Abatement Alternatives Selected by Combining Continuous and Single Event Simulations," Proc. of National Symposium on Urban Hudrology, Hydraulics and Sediment Control, University of Kentucky, Lexington, pp. 1-9, July 1976.

174. Geiger, W.F. "Urban Runoff Pollution Derived from Long-Time Simulation" Proc. of Naitonal Symposium on Urban Hydrology, Hydraulics and Sediment Control, University of Kentucky, Lexingotn, pp. 259-270, July 1975.

175. Eckhoff, D.W., Friedland, A.O. and Ludwig, H.F. "Characterization and Control of Combined Sewer Overflows, San Francisco," Water Research, Vol. 3, pp. 531-543, 1969.

176. Putnam, A.L. "Effect of Urban Development on Floods in the Piedmont Province of North Carolina," USGS Open File Report, Water Resources Division, Raleigh, North Carolina, 1972.

177. Anderson, D.G. "Effects of Urban Developemnt on Floods in Northern Virginia," USGS Water Supply Paper 2001-C, 1970.

178. Water Resources Engineers and The Hydrologic Engineering Center "Management of Urban Storm Runoff," ASCE Urban Water Resources Research Program, Tech. Memo No. 24, NTIS-PB 234 316, May 1974.

179. James, I.C. "Flood Runoff from Partially Urbanized Areas, Wichita, Kansas," USGS Open File Report, District Office, USGS, 1950 Avenue A, Campus West, Lawrence, Kansas 66045, June 1967.

180. Zuidema, F.C. "Urban Hydrological Modeling and Catchment Research in The Netherlands," ASCE Urban Water Resources Research Program, Tech. Memo No. IHP-10, NTIS-PB , January 1977.

181. Blaszczyk, P. "Urban Runoff Research in Poland," ASCE Urban Water Resources Research Program, Tech. Memo No. IHP-11, NTIS-PB , February 1977.